The Montana Science and Technology Action Agenda

Montana Science and Technology Advisory Council

October 1992

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Department of Commerce
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Letter of Transmittal

October 1, 1992

The Honorable Stan Stephens
Governor of Montana
State Capitol Building
Helena, Montana 59620

Dear Governor Stephens:

In our June 1991 Policy and Plan, the Montana Science and Technology Advisory Council outlined processes through which Montanans, working together, can prepare themselves and their State for the future. Based on that Policy and Plan, we have, with the help of many involved and concerned Montanans, developed this Action Agenda to continue moving our state toward a prosperous twenty-first century.

Eight focus groups, together more than one hundred fifty people, worked to identify industry needs and interests and develop an action plan based on their findings. Included in their recommendations are specific actions for education, industry, research, and government. The Action Agenda evolved from the input of the Council and those focus group reports, summarized in the last chapter of this publication. Unabridged focus groups reports are available through the Montana Science and Technology Alliance.

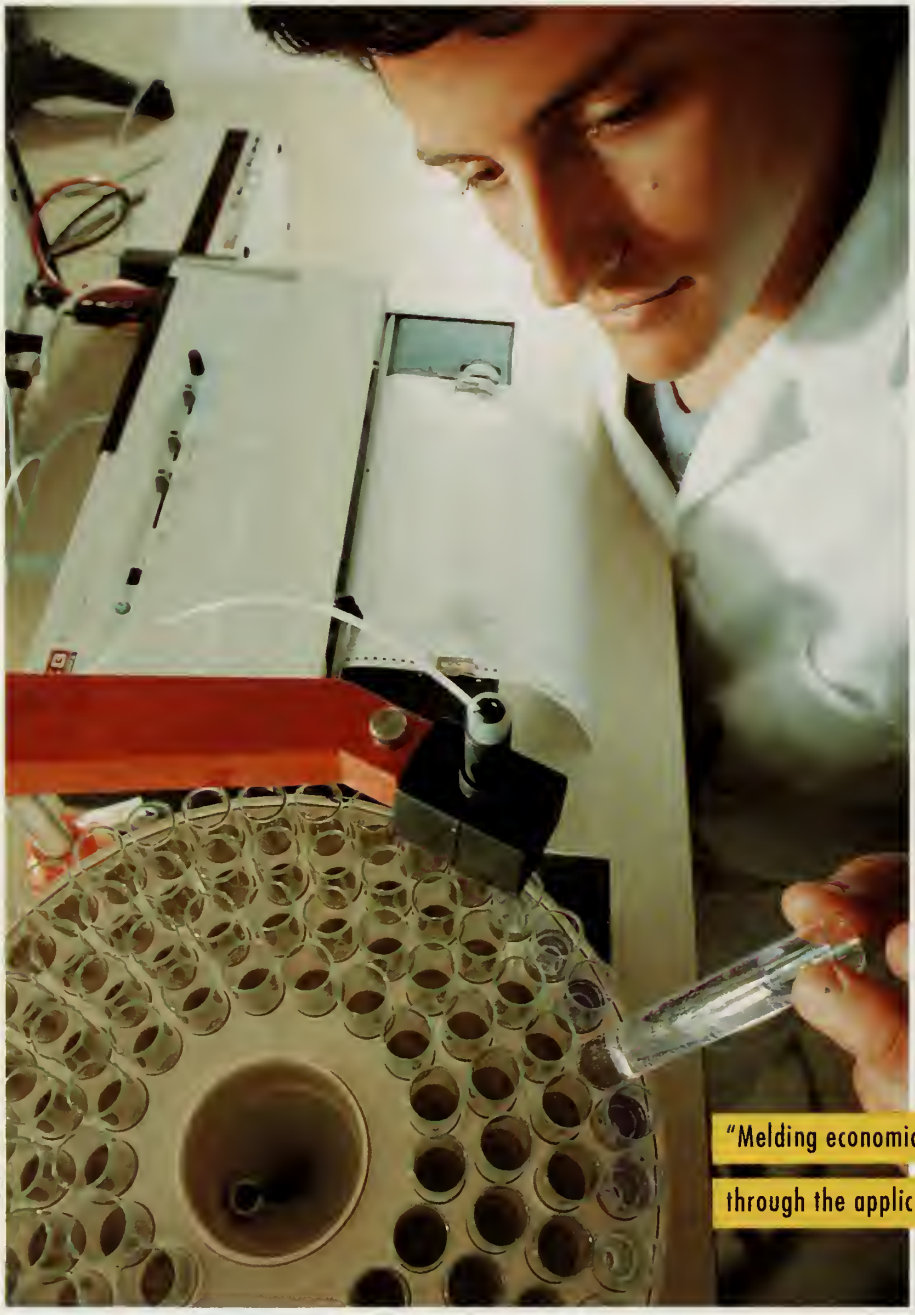
These actions require work on the part of all of us. As Governor, your personal interest in this effort has been very positive. We strongly solicit your continued support. Also, we hope that you will work to assure that our new governor, our legislature and all our citizenry commit themselves to this effort. A major commitment is outlined in this Action Agenda. This commitment will take time to accomplish. So we must start now! For Montanans to be able to hold secure, well paying fruitful jobs in the future, and for Montana companies to start up, expand and be internationally competitive—these are the goals and results that such commitments will create.

We must strive for quality and excellence by melding economic development with responsible stewardship through the application of science and technology. Such an endeavor will create a better economy and a better place for us and our children as we move into the next century.

Sincerely,

Robert E. Ivy, Chairman
Montana Science and Technology
Advisory Council

Ray V. Tilman, Chairman
Montana Science and Technology
Development Board



Ribi ImmunoChem Research, Inc. research & development technician collecting biochemical fractions of immunostimulants for basic research use.

"Melding economic development with responsible stewardship through the application of science and technology"

Bryant Photographics/Photo courtesy of Ribi ImmunoChem Research, Inc.

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Montanans live here because we love it, and we love a challenge. Through the years Montana's population has been challenged repeatedly to see if we can survive as individuals as well as a state. Today is no different. The testing continues and survival hangs in the balance.

In today's global economy, Montana's survival depends on our ability to carry on a tradition of "doing what needs to be done," however complex. We have to function in a world of sophisticated technology at a speed commensurate with what's happening around us. To keep pace with the changes an immediate investment in ourselves is required. That investment is the job of our state government, our state legislature, our University system, educators, farmers, ranchers, miners, the entire private sector. Every economic sector in the state has a stake in what we have outlined in the document you hold in your hands. It is a job for all of us. Although the job requires costly investment to accomplish, it's not nearly so costly as losing what we have.

"In today's global economy, Montana's survival depends on our ability to carry on a tradition of 'doing what needs to be done,'..."

Determining how best and at what level to invest has been the core of our Council's mission. In June of 1991, the Montana Science and Technology Advisory Council submitted to the Governor a Policy and Plan to develop and apply science and technology to meet the needs of Montana's basic industries to help secure their future. This Action Agenda builds on that foundation. It is an outline for success gleaned from the work of hundreds of key people who, up to now, have kept the wheels of basic Montana industry turning. They willingly volunteered their efforts and continue to volunteer support because they understand the imminent importance of the application of science and technology to their industries to keep those wheels turning profitably.

Industrial and research sector focus groups from across the state worked long and hard to identify ways Montana's science and technology resources could work to Montana's benefit. Volunteers, representing a statewide cross section of industry, labor, academia, government, and environmental interests, met repeatedly to develop recommendations specific to each of their industry areas. (Their unabridged reports are available through the Montana Science and Technology Alliance.)

This Action Agenda represents what the Montana Science and Technology Advisory Council, based on the focus groups' input and recommendations, feels must be done within each of the industries represented to move Montana and her people into the future in the context of a global economy. It is an Agenda that will not wait. Montana must move in tandem with the rest of world or be left behind. We must start now!

The price of this Agenda is high. The price of ignoring this Agenda is higher still. It will cost Montana, over the next eight years, $140 million of coal tax money (currently set aside for investment in the future) to do what we recommend. Doing it stands to net

Area	93-95	95-97	97-99	99-01	8 Yr. Total	Leverage Funds	Remarks
Seed Capital	8M		10M		18M	125M	1:1 match required (18M + 18M =36M); plus 2.5:1 match from equity, grants, etc. ($89M + 36M = $125M)
Special Research Centers	6M	6M	6M	6M	24M	75M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Biotechnology	10M	10M	10M	10M	40M	120M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Basic Research	10M	10M	7M	7M	34M	100M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Focus Group	8M	8M	4M	4M	24M	25M	1:1 leverage is anticipated from private fundings and possible federal match
Totals	42M	34M	37M	27M	140M	445M	

the state $445 million in outside money. Not doing it sets us up for immediate exploitation and future decline. With stakes like these, can we afford inaction based on ignorance?

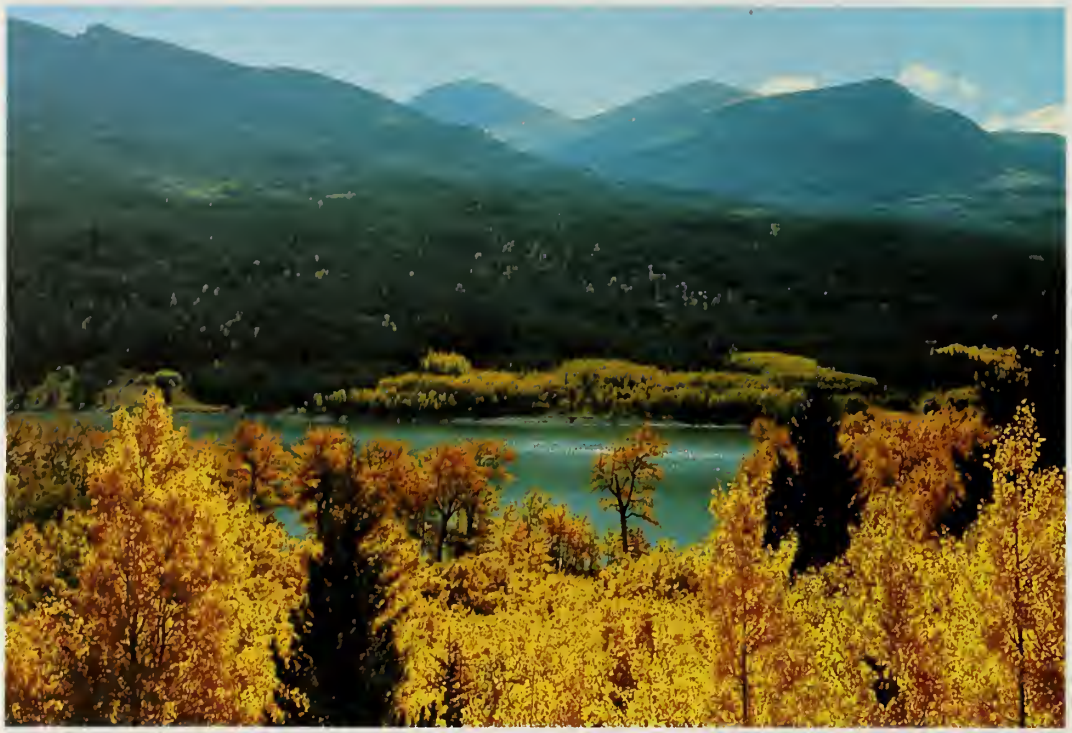
We are a naturally rich state. The contributions and applications of basic research to those natural riches have put Montana in a good position to meet the time tests of the future. Essential, wise and timely investment is the key. What those investments should be is set out in detail in this document.

We have much in which to invest. Montana's abundance of natural resources... gold, silver, coal, oil, rangelands, forests... is the envy of nations. We have a variety of mature industries, a pool of available workers, a good supply of basic materials to be researched, and a cadre of fine scientists in residence. We have some first class physical facilities with exceptional instrumentation and significant, but uncentralized resources for science and technology as a whole. Montanans themselves are our greatest asset, well educated, with a strong work ethic.

We also have some basic problems. There are major stumbling blocks to efficient use of our assets. Research and engineering programs throughout the University System are seriously underfunded. Montana lost major federal funding through the National Science Foundation EPSCoR program in 1991 because of a perceived lack of commitment to science by the state. They cited the poor level of funding of our University System, the lack of a research agenda and of central state coordination of science.

Government is viewed as an adversary, or at best an unwelcome administrator imposing often contradictory regulations at every level. Successful applications of research and technology to enhance economic development requires government to play an enabling role. Although Montana's K-12 education system is highly rated, it is not preparing students to meet the needs of Montana industries. Job applicants demonstrate a good work ethic, but the majority do not have basic skills for success: reading, writing, math, communication, problem solving; and, almost none have specific technical skills or an international perspective.

Montana industries themselves need help becoming competitive. None of our basic industries, from agriculture to forestry, mining, and energy has a solid grasp of its inventory of resources. They seriously lack adequate and reliable information for long-range decisions regarding resource availability, ecological effects of resource



utilization, economic consequences of resource management choices, appropriate research and development; the list goes on. There is little history of cooperation and coordination among Montana industries and university programs. There is no consistent process for transfer of intellectual property. That link between basic research at the universities and Montana's economic development must be maintained and strengthened. There is also a lack of communication within, among, and between industries, universities, and government.

Despite best intentions, disincentives to economic development abound in Montana. While beyond the scope of this Action Agenda, they must be addressed for Montana to meet today's tests for tomorrow's survival. Our state's decision makers need to take a close look at our tax structure, insurance and bonding issues, transportation rate structures, price and availability of power, and the availability of commercial capital.

True to its pioneering spirit and love of challenge, Montana has already established some processes to smooth the flow to the future. As a result of the 1991 Policy and Plan, a Montana Technology Discovery Network is being created to link industry clients with resources and service providers. As denoted in this Agenda, the network needs to be fully implemented. Media and direct contact programs have been developed to enhance public awareness about the role of science and technology in Montana's economic development. But, while production of materials and program implementation have begun, activity must increase when more funds become available.

Some funding mechanisms are in place. Within the State, the Montana Science and Technology Alliance seed capital and research and development programs have the structure and expertise to assist in the development and application of science and technology. The federal EPSCoR program also has matching dollars available for competitive science projects in Montana once we meet their criteria.

The key elements of this Action Agenda are intended to help remove stumbling blocks and make the most effective use of our assets and resources to meet our future which is so reliant on science and technology advancement and application. The Agenda includes recommendations for material resources, human resources, institutional resources, and communications, networking, and funding. It includes recommendations on research and research infrastructure, waste utilization, comprehensive resource inventories, education and retraining, technology transfer and regulatory conformity.

Additionally, we have delineated the need for a Montana Business Technology Institute as a core resource center for Montana industry.

What will this effort do for Montana in the next ten years? What is the vision for our state—its resources, its businesses? What we envision is:

- increased exporting of value-added Montana products;
- more of our highly educated children holding higher paying jobs here in Montana;
- more efficient, effective and ecologically sound use of our natural resources;
- increased birthing of high tech companies within our state while also attracting more high tech companies into Montana such as biotechnology, hazardous waste clean-up, laser optics and more;
- new jobs in value-added industries, in research, in new technology-driven companies, in a more competitive manufacturing sector and in the service companies that support these firms;
- creation of an expanded economic base thereby stabilizing our state and local tax revenues;
- transference of our University System's valuable intellectual property into the commercial marketplace thereby adding economic value to Montana; and
- creation of a statewide research and development structure that provides practical and valuable answers to society's needs in agriculture, energy, mining, forestry, manufacturing, health care, the environment and the quality of life here in Montana.

What do you, personally do to rise to the challenge? As the individual, the taxpayer, the potential benefactor of this Action Agenda, you need to read the Agenda and understand where you fit. Envision how your profession can be enhanced by science and technology. Formulate plans for adding value to your product. Then convince your legislative representative to support your plan and your future. And if you are a legislator, we encourage you to see the value of the Science and Technology Action Agenda and how it will enhance the quality of life as well as future hopes and dreams of your constituents. Pick up the gauntlet and enact the enabling legislation which will allow this Agenda to propel the state into determining the future rather than being determined by the future.

The Montana Science and Technology Advisory Council (MSTAC) identified six action items common to all focus group recommendation reports. These constitute the body of our action plan and the items in the total funding package. If funded as recommended, and with proper legislation, these components will help develop and apply science and technology to meet the needs of Montana's industries — agriculture, mining, forestry, energy, communications, manufacturing, service industries, etc. — for the betterment of the people of Montana.

Key Elements of the Action Agenda

Activity Area	Key Actions	Responsible Parties	When
Material Resources	1. Focus Montana basic research, biotechnalagical research, applied research, and market research an efforts that reflect the needs af Mantana industries, specifically: a. impraving rangeland; b. special characteristics af grasses; c. gamefarming/tuberculasis vaccine; d. impraved livestack seed stack; e. packaging fram plant starches; f. cattle bred ta feed an knapweed; g. higher sugar cantent grains far fuels; h. ethanal; i. energy extractian/praductian by-product clean-up; j. biaremediatian/biatech applicatians far waste treatment; k. bialeaching; l. new mineral and energy extractian pracesses; m. recavery af heavy metals; n. waad waste/preservatian; a. scientific basis far sustainable farestry; p. waad harvest research; q. alternative uses far wheat, alfalfa, aats, beets; r. immabilizatian af pallutants; s. adding value ta ar finishing praducts befare they leave the state; t. efficiencies in energy delivery and utilizatian; and u. laser materials and electra-aptic devices.	MSTA Advisary Cauncil, MUS Executive Research Cammittee, MSU Veterinary Science Lab, Plant Sciences Center, Special Research Centers; Waste Technalagy Center, Mantana Tech	1993 - 2001
	2. Encaurage the use af waste praducts as energy resaurces ta help salve waste dispasal prablems and pravide alternative saurces af energy.	MSTA Advisary Cauncil	1993 - 2001
	3. Appaint a task farce ta explare and define a.) the scape af a camprehensive inventary af materials, resaurces, pracessing capabilities, research in pragress, key cantact peaple, etc., in state and aut af state, far each af the industries affected by the Actian Plan, and b.) develapment af an electranic directary af the inventaries an METNET, Big Sky Telegraph, ather existing bulletin baards, and in public libraries.	MSTA Advisary Cauncil, vice presidents far research at the universities, MUS Executive Research Cammittee, and representatives af private industry	1993 - 1994
Human Resources	1. Establish a secandary schaal level skilled trades curriculum reflecting the needs af Mantana industry.	Office af Public Instructian, lacal schaal baards, Department af Labar and Industry, industry representatives	1993 - 1994
	2. Train peaple in business ta use new research and technalagy ta increase their ecanamic competitiveness.	University Technical Assistance Pragram (UTAP), Mantana Business Technalagy Institute, Cammissianer af Higher Educatian	1993 - 2001
	3. Establish a daily shuttle service between UM and MSU with a stap at Mantana Tech ta enable students and researchers ta take advantage af the resaurces af ather campuses.	UM, MSU, Mantana Tech	1993 - 1994
	4. Offer a university degree in grain technalagy (faads, fuels, and alternative uses) ta prepare students ta help salve Mantana prablems and develap Mantana jabs.	Baard af Regents, Cammissianer af Higher Educatian, industry representatives	1994 - 2001
	5. Enhance vacatianal-technical training ta meet the needs af industry in the geagraphic areas they serve.	Cammissianer af Higher Educatian, Cauncil an Vacatianal Educatian, industry representatives	1993 - 2001
	6. Expand appartunities far teachers ta learn mare abaut basic Mantana industries thraugh internships during the summer and far classes af all grade levels ta taur industries thraughaut the schaal year.	Office af Public Instructian, Cammissianer af Higher Educatian, industry representatives	1994 - 2001
Transfer of University Technology and Expertise to the Public	1. Create a pasitian within the Office af the Cammissianer af Higher Educatian ta establish and administer a unifarm methad af priaritizing, patenting, and marketing intellectual praperties and ta develap technalagy partnerships with private industry.	Cammissianer af Higher Educatian in caardinatian with MSTA and MSTAC, MUS Executive Research Cammittee, and the caaperatian af university vice presidents far research	1993 - 2001
	2. Allacate a small fund that cauld be applied quickly ta pratect discaveries made in University units.	Cammissianer af Higher Educatian in caardinatian with the new technalagy transfer pasitian	1993 - 2001
	3. Organize tech-transfer seminars ta get industry, university researchers, and ather interested parties tagether.	MSTA, MSTAC, Cammissianer af Higher Educatian, new technalagy transfer pasitian, MUS Executive Research Cammittee, universities and calleges	1993 - 2001
Institutional Resources	1. Streamline the permitting pracess far industry by instituting "ane stap permitting" at the State, designating a lead agency far each industry ta caardinate all permitting far the industry.	Rural Develapment Cauncil, State Gavernment permitting agency directars, MSTAC, industry representatives	1993 - 2001
	2. Strengthen biatechnalagy infrastructure with instrumentatian and research chairs in Micrabial Structure and Functian, Nucleic Acids, Pratein and Receptars, Develapmental Bialagy, and Plant Biatechnalagy.	MSTA, MSTAC, MONTS, Universities, Cammissianer af Higher Educatian, Center af Excellence in Biatechnalagy	1993 - 2001
	3. Strengthen care university research infrastructure, especially EPSCaR.	MSTA, MSTAC, MUS Executive Research Cammittee, Universities, Cammissianer af Higher Educatian	1993 - 2001

Activity Area	Key Actions	Responsible Parties	When
	4. Strengthen special centers of research, especially the Center for Interfacial Microbiol Process Engineering Research Center, the Center for Advanced Mineral Processing, the Center of Excellence in Biotechnology, Deaconess Research Institute, McLaughlin Research Institute.	MSTA, MSTAC, MUS Executive Research Committee, Universities, Commissioner of Higher Education, industry representatives	1993 - 2001
	5. Aggressively pursue federal funding for the Bioscience Center at MSU.	MSTAC, Commissioner of Higher Education, MSU	1993 -1995
	6. Aggressively pursue full implementation of the National Mine Waste Tech Center in Butte.	Montana Tech, Center for Advanced Mineral Processing, industry representatives	1993 - 2001
	7. Establish the Montana Science and Technology Advisory Council as the continuing science policy development arm of the State within the Governor's office, and expand Council membership to include the chairs of industry focus groups.	MSTAC, Governor, Legislature	1993
Communications /Networking	1. Establish a nonprofit Montana Business Technology Institute to facilitate and nurture the growth of business and industry in Montana.	MSTAC in coordination with the Montana Competitiveness Council, the Montana Manufacturers' Association, the Montana Society of Manufacturing Engineers, and UTAP	1993 - 1994
	2. Establish an automated bid list to provide Montana businesses with immediate access to opportunities to compete for government contracts.	Montana Business Technology Institute, Montana Department of Commerce, industry representatives	1994
	3. Support the EQC and MORE/EPSCoR project objectives to enhance Montono's energy industry.	MSTAC, Commissioner of Higher Education, EQC	1993 - 2001
	4. Establish a Coalition for Fossils and Groins Fuels Energy Research to stimulate communications among players within the energy industry.	MSTAC, MUS Executive Research Committee, industry representatives, Universities, Clean Coal Technology Center	1993
	5. Support the effort to create wood products manufacturing networks to improve industry competitiveness.	Montana Competitiveness Council, MSTAC, industry representatives	1993
	6. Make Cooperative Extension information readily accessible by electronic media, including modem, satellite, and fiber optics, and provide easy access via electronic media to compiled data base information and the University library system.	Commissioner of Higher Education, MSU, Cooperative Extension Service, industry representatives	1994
	7. Establish and strengthen the Montono Technology Discovery Network to help each enterprise in Montana obtain, on a continuing basis, the technological and related business information it needs to go into business or stay in business.	Rural Development Council, Cooperative Extension Service, service providers	1993 - 1995
Funding	1. Expand funding available to provide for seed capital financing.	Legislature, Governor, MSTA Board, MSTA	1993 - 2001
	2. Provide funding to support the special research centers, especially the Center for Interfacial Microbiol Process Engineering, the Center for Advanced Mineral Processing, the Center of Excellence in Biotechnology, Deaconess Research Institute, McLaughlin Research Institute.	Legislature, Governor, MSTA Board, MSTA, Commissioner of Higher Education	1993 - 2001
	3. Provide funding to support biotechnology research expansion in Microbiol Structure and Function, Nucleic Acids, Protein and Receptors, Developmental Biology, and Plant Biotechnology.	Legislature, Governor, MSTA Board, MSTA, Commissioner of Higher Education	1993 - 2001
	4. Provide funding for basic research infrastructure.	Legislature, Governor, MSTA Board, MSTA, Commissioner of Higher Education	1993 - 2001
	5. Provide funding to enable focus group related projects including support for inventories, value-added research projects, technology transfer initiatives, technology deployment, and communications/networking.	Legislature, Governor, MSTAC, MSTA, Commissioner of Higher Education	1993 - 2001
	6. Authorize funding for a position within the Office of the Commissioner of Higher Education to establish and administer a uniform method of prioritizing, patenting, and marketing intellectual properties and to develop technology partnerships with private industry, with profits benefitting the researcher, research institute, and the State.	Legislature, Governor, Office of the Commissioner of Higher Education, MSTAC, MSTA	1993 - 2001
	7. Begin $250,000,000 fundraising campaign when commitment is secured from the State for the Action Agenda.	Legislature, Governor, MSTAC, Commissioner for Higher Education, Universities, focus groups	1993

1) Value-Adding

Focus Montana State-supported research and technology on processes that can add value to Montana products.

Montanan's tax dollars should support research and technology that benefits Montanans by adding value to our products and services. The "value-added" concept is inherently a marketing effort supported by a manufacturing process to meet a need in the marketplace. Mining waste clean-up, improved use of "waste" forest products, and a variety of other important concerns in our state can be addressed only through manufacturing processes. Montana also has an abundance of elements that could be combined, processed, and manufactured into useful finished products. In some cases, value can be added by substituting a Montana component for one traditionally purchased out of state. In economic terms, this "import" dollar saved is just as important as an "export" dollar earned.

"Montanan's tax dollars should support research and technology that benefits Montanans by adding value to our products and services."

■ ■ ■

Value-added Opportunities

Here are some basic steps that can be taken within the sectors to add value to Montana industries:

Animal Agriculture:

- Harmonize Montana standards with U.S. and global standards;
- Improve utilization of basic resources, including rangeland resources;
- Improve our lead in performance testing production of quality seed stock;
- Explore the market for developing a small to medium sized packing facility specializing in the production of certified Angus beef and other high quality beef, positioned for both domestic and export markets;
- Develop better breeding stock through genetic manipulation, genetic engineering, and disease resistant genetic pools;
- Optimize the range eco-system, i.e. livestock, wildlife, and/or fisheries and water so that more dollars can be realized from an economic unit, perhaps by leasing hunting and fishing rights in conjunction with the livestock operations; and
- Improve fisheries and wildlife habitats.

Plant Agriculture:

- Take advantage of opportunities for special niches and/or multiple coproducts, for example: small flour mills and bakeries that take advantage of our special wheats; micro-breweries; a modern ethanol plant that extracts vital gluten from high protein wheats and produces carbon dioxide, distillers dried grains, electricity, and ethanol. It could also supply heat for green houses or some other use;
- Use current waste products from smaller plants to make substitutes for some wood products to ease the pressures on our forest resources;
- Develop processing facilities for alfalfa, canola, and other plants well suited for theproduction of specific compounds or oils; and

- Use plant products for biodegradable containers for fast food packaging and other consumer product packaging to relieve pressure on landfills.

Communications and Manufacturing:

- Identify specific technical assistance needed and provide direction to resources or provide direct assistance as a trade association service;
- Build and document a broad network of Montana manufacturers who are certified to international ISO-9000 quality standards;
- Develop partnerships to handle multiple levels of the manufacturing process;
- Identify fabrication and supply requirements of manufacturers in the state, communicate these needs with potential suppliers, and facilitate collaborative efforts to develop more vertical value-added manufacturing within the state;
- Aggressively explore opportunities to perform a manufacturing step in-route for products being shipped through Montana; and
- Provide automated summaries of daily government contract bid lists and other requests for proposals.

Energy Resources:

- Use "hog" fuel and other waste materials to produce power; and
- Explore opportunities to recycle waste oil and grease in Montana.

Bryant Photographics/Photo courtesy of Ribi ImmunoChem Research, Inc.

Ribi ImmunoChem Research, Inc. production technician operating a large-scale bacterial fermenter.

Minerals Extraction and Processing:

- Manufacture fertilizer. Montana has a ready supply of natural gas (for ammonium nitrate) and sulphur, phosphate rock, and limestone — key ingredients for fertilizer. We also have a substantial in-state end user in agriculture;
- Manufacture blasting agents. Ammonium nitrate from natural gas is also an oxidizer and essential component in blasting agents commonly used in the mining industry;
- Manufacture pH control products. Limestone could be manufactured into soil conditioners or environmental remediants;

- Manufacture plastic prills. Montana has the petroleum products and talc to manufacture plastic prills, the basis for plastic extrusion products;
- Add a die-casting facility in Montana to produce and assemble many products, such as gear boxes, irrigation nozzles, etc., entirely in-state;
- Investigate potential uses for low grade or "dirty" talc, which represents 50% of Montana's talc. Talc seems to have spinoff possibilities in oil spill clean-up, insulation, plastics, catalytic converters, ceramics, dry lubricant, and paint manufacture;
- Use waste as an alternate source of energy;
- Recycle old tires (now considered hazardous waste) into asphalt and pavement top-coating;
- Institute a return/reuse system for fifty-five gallon shipping/storage drums, now being stock-piled in hazardous waste dumps;
- Explore the market for a smaller volume aluminum recyclery with the capacity to remelt scrap into "sow";
- Add a level of value to raw or crude products by milling and bagging;
- Add the next quality level to foundry castings to compete for a greater range of higher spec opportunities;
- Research the availability of Montana olivane sand for foundries;
- Research the potential for a die-casting facility and smelter capable of processing a variety of ores; and
- Produce cement castings such as highway dividers and railroad ties as well as bulk and bagged products. For instance, cement railroad ties would relieve the pressure on the forests by using Montana's abundant limestone resources to replace wood in this low end-use wood product.

Forestry and Wood Products:

- Provide basic wood science education and technical assistance to wood product manufacturers;
- Use waste wood fiber in the production of alternative building materials and other innovative products; and
- Develop attractive and cost-competitive decking, etc., for homeowners to help conserve needed wood for more appropriate uses.

Adding value to Montana products and processes can enhance our environment, provide jobs for Montanans, and generate substantial additional tax income for the State. Adding value will also help keep industry in Montana, attract allied industries, and create finished, consumer-use products in Montana.

Research requirements

Any efforts to continue adding value to Montana products will require ongoing research.
Following is a comprehensive list of research requirements identified by the industry focus groups:

Animal Agriculture

- Optimol livestock production in o rangelond setting
- Rangeland livestock/wildlife co-relationship
- Livestack and/ar wildlife impravement af the rangeland eco-system
- Animal biology, emphasizing appetite and diet, stress and disease
- Tronsgenic technology
- Early pregnoncy tests
- Modification of onimal products far fot ond other characteristics
- Inexpensive, easily used diognostic tests, chemoprophyloctics, chemotheropeutics ond voccines
- Tronscription factors ond other regulatars af gene expression
- Regulation af cellular functions (growth factors, tronscription factors and second messenger systems)
- Nutrient requirements of onimols to produce desirable faad quolities
- Gene mops of onimol species ond of disease-causing microorgonisms
- Biologicol ond genetic enhancement af onimal efficiency
- Improvement of nutritionol quolity, composition and safety of onimal products
- Improved rongelonds and range utilizatian
- Diseose control in game animols, tuberculosis, brucellosis
- Madern genetics
- Physiology
- Animol health/treotment ond especially treatment of diseose
- Vaccines
- Bosic molecular biology, especiolly os regards animal healh
- Animol immune systems
- Bialogicol ond genetic enhancement of onimal efficiency
- Improving nutritional quolity, compasitian and sofety of animol products
- Gene identificotion, mapping, tronsfer, etc., especially far gene-reloted diseose susceptibility ond resistonce
- Composition of animal products ot the molecular level

Multiple Industry Applications

- More efficient use of our water resources
- Speciolty grosses
- Degrodotion of noturol resources
- Sustainobility of ogricultural systems
- Riporion plonts that could be used to better stabilize streom banks ond provide food and cover for wildlife
- Plant vorieties that ore torgeted far certain monogement systems, including livestock praduction, wildlife production, reclomotion of disturbed or degraded (e.g., saline) sails and soil stobilizotion

Plant Agriculture

- Bio-control/mitigatian af weeds, insects, diseases, and other pests
- Impraved strains of traditionol plonts ond possibly plonts new ta Montona
- Crop monogement systems
- Allelopothic traits
- Wheot, borley, oots, ond sugar beet varieties precisely developed for ethonol production and other praducts
- Specific barley varieties far human food, animol feed ond malt
- Wheat and borley vorieties developed for alternative products, e.g. specific industriol uses
- Alfolfo vorieties thot produce pharmaceuticals or cosmetic compounds
- Precisely defined oils in canolo ond sofflower
- Turfgrass vorieties for precision management
- Bioreplocements far fats, plastics, insulotion, construction moterials, and items that now find their woy into londfills, omong other things
- Medicinal/industriol potential of indigenaus plonts to see if they have medicinol or industriol uses that we have not yet found
- Indigenous "Host" plants for production of useful ond profitoble substonces.
- Plants nat currently grown here that might have useful troits
- Development of varieties af plants especiolly suitoble to Montono's conditions af sail and woter
- Suppressian of diseose

Forestry and Wood Products

- Multiple farest entry strotegies, benefits, and constraints to help achieve a reasonoble bolonce between wildlife habitat preservotian cancerns ond the need to more effectively utilize available fiber, eliminoting unnecessary woste
- Minimizing oir pollution problems frequently ossociated with the burning of wood woste
- Preserving the useful life of wood products
- More productive use of ovoiloble trees
- Lighter, but stronger, structural wood products
- More effective use of smoll diometer larch
- Waad chemistry
- Bosic chemistry of biamass utilizotion
- Horvest techniques
- Landscape ecology

Energy Resources

- Clean coal technalagies such os sulfur removol from Western coals, and coal canversian, e.g. liquefoction
- Coal drying technologies
- Magnetohydrodynamics
- Wind turbines
- Pumped starage and noturol gos vehicles

Minerals Extraction and Processing

- Enhonced leaching/bialeaching
- Water clean up
- Surfoce remediatian
- Resistant plont species
- Removol of toxics from the soil
- Metal ian uptake
- Creotion of wetlands
- Immabilization of potentiol pollutants
- Thermodynamic praperties of minerols os o functian af minor-element compositian
- Activity coefficients of oqueous species at high ionic strength ond development of speciotion models using these ion interactian madels
- Phose equilibrium models far metol systems
- Rate and mechanism of mineral water interactians
- Rote ond mechanism af metol corrosion processes
- Physical and chemicol stobility of callaidal systems used for explosives
- Stobility of collaidal suspensions in oqueous systems - determination of the point of zero-chorge ond of the critical micelle region
- Predictian of interfociol tensions of aqueaus systems versus the composition ond concentration of dissolved constituents
- Equotion of state af adsarbed monoloyer molecules
- Identification of oqueous complexes
- Synthesis of new surfactants ond frothers
- Basic chemistry of remediotion af mining-reloted envirannentol degrodotion
- Reseorch in oreos that will improve the efficiency af metal ar other mineral extractian, environmentol performance (both new techniques in mining and new remediation praceses)
- Research directed toword increosing value added to extrocted minerals

2) Comprehensive Inventories

Conduct a comprehensive inventory of materials, resources, capabilities, research, and key contacts for each focus group area.

Enough has been learned about the environment to convince people on both sides of the controversies that complex interrelationships exist in nature, and that the long-range effects of change (whether brought about by the forces of nature or through the actions of man) are just beginning to be understood. Successful multiple resource management requires careful analysis of the interrelated effects of proposed activities on various interconnected ownerships. This kind of scientific management requires the support of a comprehensive inventory system.

"Management of natural resources extends beyond Montana, and these issues have regional if not global implications; . . ."

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We also need a comprehensive inventory of our unique resources and unique properties and characteristics of existing products and processes to succeed in the global arena where Montana companies compete with foreign government-subsidized companies and companies from developing nations with no environmental protection considerations. This kind of inventory will also delineate Montana's supply of raw materials, essential to encouraging the retention or expansion of primary or value-added manufacturing in Montana. Financial institutions, as well, will certainly require applicants for plant modernization or improvement loans to demonstrate their ability to obtain enough materials to meet production projections.

The cost of not having needed inventory information, or of not being able to use it to its full potential, already has been very high in Montana. For instance, one of the major aspects of the timber supply problem now developing is the inability of the national forests to sell the full volume of timber projected under the forest plans. The shortfall in the national forest program is due at least in part to the inability of the federal land managers adequately to anticipate the cumulative effects of harvests on intermingled ownerships — and the impacts of these cumulative effects on future sales on national forest lands. This caused the U.S. Forest Service to be overly optimistic in its planning in terms of the volume of timber that could be harvested, and it caused the forest products industry in the late 1980s to anticipate more timber than the national forests could deliver. Just the cost incurred by the industry and the Forest Service (as a result of the national forests' inability to accurately project the volume of timber they could bring to market) would have funded a substantial integrated forest resource inventory.

Management of natural resources extends beyond Montana, and these issues have regional if not global implications; but an in-state inventory is a good place to start. We recommend a comprehensive inventory of materials, resources, capabilities, research, and key contacts for each focus group area. Such an inventory system would be complex. A good first step would be to conduct a comprehensive multiple resource inventory to evaluate what is actually being done in Montana with multiple resource inventories against what is technologically possible

and feasible. The evaluation should lead to recommendations for the development of a comprehensive inventory system for Montana resources. The recommendation from the Forestry and Wood Products Focus Group provides an excellent model. That group recommends funding a task force to explore and define the scope, resource requirements, time lines, costs, and potential sources of funding for a comprehensive inventory system.

A major concern is Montanans' willingness (or unwillingness) to accept a scientific basis for decisions regarding sustainable industries if it means downsizing the workforce during the interim. Comprehensive inventories represent the first step in such a scientific approach to managing sustainable industries that are (1) individually and societally practical and economically gainful; (2) biologically possible; and (3) culturally acceptable. Federal funding will be required to support the research needed to establish such a scientific basis, but the State of Montana should work with its Congressional delegation to try to get as much as possible of that research done in Montana.

3) Communications and Networking

Provide Montana industries with easy access to information through state-of-the-art communications and networking.

As Montana industries add value to products and processes to compete in the global arena, they will need easy access to up-to-the-minute information.

Harley Hettick/Photo courtesy of Travel Montana

Montana Technology Discovery Network

The Montana Technology Discovery Network can play a major role in providing access to appropriate resources by bringing together expansion companies, manufacturers, entrepreneurs, and other customers with economic developers, University contacts and other resource providers. The Discovery Network can help existing firms obtain and use the technology they need to

A UTAP staff engineer is observing a worker in order to perceive the steps involved in making a product. Based on this observation UTAP engineers make recommendations for improving efficiency.

remain competitive, to develop new enterprises that can succeed and grow using new technologies, and to help commercialize new technology developed in Montana's industry, universities, private research institutions and federal laboratories. The Discovery Network will link business and industries with service providers statewide who can respond to requests for information, technology assistance, training, or managerial and financial assistance.

The Discovery Network also provides a critical link between the efforts of the Montana Competitiveness Council to stimulate client demand for technological competitiveness and resources already available within the state to meet that demand. The Montana Competitiveness Council is a nonprofit, nonpartisan organization representing private industry, local economic development organizations, universities, labor, and government organizations. Its purpose is to stimulate collaborative efforts among businesses to increase competitiveness, modernize production, expand workforce training, and create flexible business networks to bring businesses together to achieve what they can't accomplish alone, and launch collaborative efforts among small firms to confront and overcome common problems. Network collaboration can help Montana businesses share costs and resources to achieve economy of scale, add value to raw materials, and modernize and expand manufacturing capabilities. The process will be coordinated by "network brokers" who work directly with manufacturing business owners and workers to advance processes, expand product lines, improve day-to-day business flow, and identify and secure new markets for Montana- made products and processes.

Montana Business Technology Institute

We also recommend creation of a Montana Business Technology Institute, as a nonprofit organization, to be established with federal and private funds, to provide a point of contact for Montana manufacturers and people looking to do manufacturing work. The Institute would provide critical networking within existing state and university organizations to maximize the impact of these resources. The Institute would require a relatively small staff trained as manufacturing network brokers to connect producers and markets. It would draw heavily on existing state and university entities such as the University Technical Assistance Program and the Entrepreneurship Center, already involved in support of manufacturing operations. The activities of the Institute might include:

- Education and Training: manufacturing network brokering; international ISO-9000 quality standards; manufacturing productivity and competitiveness.
- Information and Communication: computerized data-base directory; bulletin board and key-search capabilities; inventory of Montana manufacturing and communication capabilities.
- Brokering: matching industry research needs with available expertise; encouraging development of industries particularly suitable for Montana.
- Research: economic and social research relative to the needs of Montana industry.
- Coordination: identification of technical assistance needs and referral to resources; opportunities to test technology and equipment in cooperation with the new MSU Engineering and Physical Science facility's computer-integrated manufacturing lab; identification of critical test/instrumentation industry requirements and available testing equipment and services; coordination of industry-specific technical assistance. The Institute might also provide long-term pilot plant installations helpful to Montana industries.

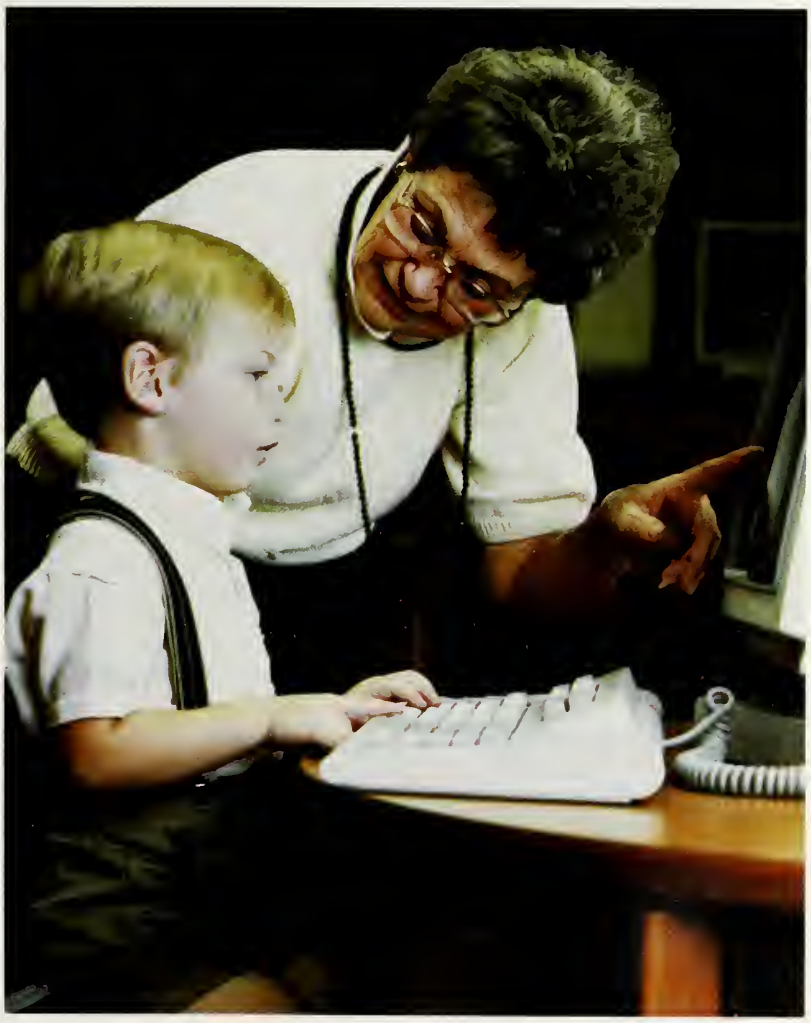
Coalition for Grain and Fossil Fuel Energy Research

We also recommend creating a Coalition for Grain and Fossil Fuel Energy Research to provide consistent communication between and among EPSCoR, the U.S. Department of Energy, and the National Science Foundation and to increase the links between the universities, the Clean Coal Technology Center, and the oil and gas producers.

4) Skill Training

Provide Montanans with technological skill training appropriate to the needs of Montana industry.

The world is changing, and the skills required to keep pace are changing as well. Technology is the key to success in the global marketplace. It's becoming a world of skilled specialists–from fork lift operators to gene machine operators. There will always be jobs for people with specific skills, whether or not they are "educated."



Gateway Software Corporation's library management software products are installed on computers throughout the country.

Unless Montanans develop technological skills, Montana will be out of the marketplace. We need to train our young adults in careers that will enable them to remain here if they choose.

Elementary and Secondary Education

Montana has an adequate labor force with basic literacy skills. However, most job applicants lack sufficient skills in communication, spelling, grammar, math, and science, not to mention technical skills, to succeed in Montana industries. Most workers have a strong work ethic, but do not understand how the American economy operates or how industry works. Typically, industries spend from 4% to 10% of their budgets to train workers in specific technical skills such as hydraulics, mechanics, welding, etc.

We need to emphasize science and math throughout K-12. In addition, we should institute a trades/vocational curriculum at the secondary school level including basic skills such as welding, operating a drill press, etc., and academic courses explaining how businesses operate.

Post-secondary Education

There is a growing need for post-secondary workers in high-tech careers, for example, energy conservation technologies, fermentation technology, tissue culturing, gene machine operator, instrumentation mechanics, etc. High school technology education and vo-tech education should emphasize modern manufacturing issues such as quality concepts and cost controls. The product cycle of vo-tech education/training is shortening just like the product cycle for many goods and services. There should be more flexibility in the system to allow timely response to changing needs. Vo-techs should offer higher-level skill training designed to meet the needs of businesses in the geographic areas they serve. The most recent survey by the Montana Department of Labor and Industry reveals that vocational education and Job Training and

Laboratory research facility at Montana State University.

Partnership Act (JTPA) programs are not supplying workers with the specific skills and skill levels for the present needs of Montana industry, let alone future needs. Vo-techs must re-examine the methods they use to decide which courses to offer and re-design their curricula to provide Montana students with skills for the future.

Collaborative efforts between public and private college and vo-tech units and with regional or national programs like the National Technology University must be explored to cost-effectively deliver useful educational programs.

The development of a Natural Resource curriculum at Montana State University (MSU) is a strong step toward improving the combined teaching of renewable natural resources and livestock/wildlife management. This curriculum will focus on the science and business aspects of natural resource management as it relates to rangeland, livestock and wildlife.

The Industrial Engineering Department at MSU must lead the way in training engineers for manufacturing positions.University business and other engineering programs should expose their students to more information on manufacturing concepts such as Just In Time, statistical process control and other quality issues associated with world-class manufacturing.

The universities and the Montana business community should work together to identify upcoming educational needs. Degrees that directly support development of Montana and help solve our problems should be strengthened, while programs weak in these areas should be refocused. For instance, Montana should offer a university degree in grain technology (foods, fuels, and alternative uses). We need to train our young adults in careers that will enable them to remain in their home state if they choose.

Employee Skill Training

Montana's broad spectrum of manufacturing firms requires a wide range of employee skills. There is a critical need to help business owners and managers understand and implement modern manufacturing methods and systems to increase productivity and improve quality while reducing costs. There are needs for engineers and for machinists; welders and computer programmers; quality assurance specialists and "thinking operators." There is also a critical need for on-the-job skills training as well as continual education and retraining.

> *"There should be more flexibility in the system to allow timely response to changing needs."*
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Skills-related education must be delivered at places and times convenient to workers. Distance learning through satellite delivery and teleconferencing offers significant opportunities. After hours use of public school or public library distance learning facilities might address this need and make more cost-effective use of public facilities and equipment.

The Montana University System (MUS) must take a stronger role in life-long learning, offering a wide range of courses at hours and locations convenient for workers. There is a real need for cutting-edge educators to provide continuing education to workers. This will require faculty develop-

ment programs and incentives. Life-long learning should be enhanced and promoted by broad transferability of course credits among all units of the University System. Transferability should extend to as broad a spectrum of training and educational institutions as possible.

The University System also should provide learning opportunities through quality, well-packaged, work/home-site delivered programs on a wide range of topics aimed specifically at Montana industries. These could include quality assurance, safety, service delivery, and so on. These programs might provide college credit, be part of technical certification programs, or both. Business managers have a critical role in providing input on specific training/education requirements to ensure these programs have application and value. Networking through telecommunications could enhance delivery of education programs statewide. For instance, quality assurance programs might originate at MSU and be cooperatively delivered through the Fort Peck Tribal College to address the Montana Indian Manufacturing Network businesses in the Wolf Point area. Each entity could add value and strengthen the process.

"Essentially all new technological industry springs from basic research."

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Negotiation and dispute resolution technologies will be of ever-increasing importance in Montana. It is anticipated that the U.S. Forest Service will be a funding source for all or part of some projects, since there appears to be a major agency emphasis on trying to measure non-commodity resource values and explore appropriate and acceptable trade-offs among forest resources.

Teacher training

Teacher education and training on new technology and information formats (i.e., CD ROM) is critical. The Technology Education organization within MSU's Department of Agriculture and Technology Education is developing ways to incorporate practical technology and production education into classroom situations. The University System should consider how this expertise can be included in all teacher preparation programs and integrated into the math and science curriculum work now underway.

Teachers also need to learn more about how business and industry work. Teacher internships during the summer are one way to expand teacher understanding through on-the-job training in industry. Under Montana Tech's National Science Foundation grant, almost all operating mines in Montana support a teacher intern on site in the summer for three weeks. Under direct supervision of the mine staff, the teacher learns about mine geology, mine production, crushers, leach pads, process plants, surveying, assaying, refining, and Mine Safety and Health Administration (MSHA) training. The teacher then uses the intern experience to prepare classroom curriculum. Participating teachers have found this to be an effective medium for teaching math and science. The mines have found it to be an extremely valuable public relations tool. We recommend expanding opportunities for teachers to intern in Montana industries during the summer and for classes of all grade levels to tour industries throughout the school year.

5) University Infrastructure

Provide Montana universities with the facilities, equipment, and staff to effectively serve the needs of Montana industry

Montana universities are not currently prepared to meet all of the research needs of Montana industries as identified in the Focus Group reports. In early times, research usually was done by extraordinary individuals with adequate leisure time, money, curiosity, and a major practical problem to solve. Not until the last half of the nineteenth century was research activity formalized with the development of groups of highly educated people working mainly in universities under the direction of a leader. This system both resulted from and drove the industrial revolution; and much of this early work led to immediate practical application, e.g., the dye, pharmaceutical and metallurgy industries, medical x-rays, radio communication, nuclear energy, and color photography. While basic research is directed toward developing new scientific understanding of a fundamental nature, it is often motivated by and is never far from use in solving practical problems of economic importance. Essentially all new technological industry springs from basic research.

We need to provide Montana universities with the facilities, equipment, and staff to attract federal matching funds and private contributions to conduct world-class research to support the development of Montana's economy.

Rocky Mountain Laboratory, McLaughlin Research Institute, Deaconess Research Institute, Montana State University, and the University of Montana (UM) provide modern biotechnology research for our state.

The federally funded Rocky Mountain Laboratory already houses state-of-the-art equipment and facilities, but the other centers will require some state and public support. The plan calls for housing 60 more principal investigators and 60 more technicians in new facilities at the two universities, in the facility under construction for the McLaughlin Research Institute in Great Falls, and in the proposed structure for the Deaconess Research Institute in Billings. The facilities would include research space for investigators, as well as core facilities to provide capabilities in Nuclear Magnetic Resonance, Mass Spectrometry, Molecular Modeling, Nucleic Acid Sequencing and Synthesis, Peptide Sequencing and Synthesis, Macromolecular X-Ray Crystallography, Electron Microscopy, Hybridoma Facility, Fermentation Facility, and a Biomolecular Characterization Facility. These facilities would be located at the various research centers and be readily available to researchers throughout the state.

Doctor Kirkpatrick of Deaconess Research Institute.

High Plains Productions/Photo courtesy of Deaconess Research Institute

R. Webster/Photo courtesy of Montana Power Company

We must aggressively pursue funding for a new building at the University of Montana and for the Bioscience Center to be attached to the Plant Growth Center at MSU. In addition, to begin meeting the needs of this Action Agenda, we recommend establishing Research Chairs in Microbial Structure and Function, Nucleic Acids, Protein Receptors, Developmental Biology, and Plant Biotechnology along with five technical positions for support. We also propose developing the Fermentation Facility capable of growing up to 250 liters of bacterial culture in variable environments such as high temperature and extreme environments. Coupled with this facility we need separate plant and animal tissue culture centers.

To provide support for basic research, we need to establish a technical support staff to help train individuals to use the complex instruments and to maintain them. Intricate modern instrumentation needs a curator for day-to-day and exceptional maintenance, to modify setups for particular projects, and to advise researchers how to best take advantage of its power. Local support is particularly critical because we are so far from major service centers. Beyond this we need centralized, competently-staffed electronics, machine shops, etc., to solve extraordinary problems with major instrumentation and to construct state-of-the-art instrumentation. Core facilities and the presence of stable and knowledgeable support staff will enhance the ability of senior investigators to obtain federal, corporate, or foundation funding for the most powerful techniques available.

We also need to maintain and strengthen Montana's special research centers — the Center of Excellence in Biotechnology, the Center for Interfacial Microbial Process Engineering, the Center for Advanced Mineral Processing, the Deaconess Research Institute, and the McLaughlin Research Institute. Their support is critical to the successful implementation of the Action Agenda.

Effective research also requires a state-of-the-art library system. Because scientific knowledge and discovery advance so swiftly, science materials in the libraries are quickly obsolete. Researchers and business people must have global access to the latest journals, periodicals, and monographs in their fields of expertise, through subscription, interlibrary loan, and electronic media.

6) The Role of Government

Refocus government activities to enable industry.

We have identified research needs and value-added opportunities that will enable Montana industry to expand while enhancing our environment. But, unless we have some way of allowing and encouraging that process to get started, this is a moot exercise. In every focus group report, government policies and tax structures were identified as a major obstacle to implementation of recommendations. The proper and desirable role of government as it relates to the development of industry in Montana should be to enable rather than encumber.

Government policy takes various forms that affect the economic climate. In turn, the economic climate plays a major role in eco-

nomic development and activity. To every extent possible the state should institute "one stop permitting" for industry. The designated agency must be knowledgeable about the permitting requirements and process. Rather than sending industry door-to-door among dozens of state agencies, one stop permitting would bring the bureaucracy to the industry. The permitting process itself should be streamlined by defining requirements for approval and implementing a standardized approval schedule with benchmarks guaranteeing government response, approval, or rejection at specific points in the process within a certain amount of time.

Montana's compliance costs are typically higher than those in neighboring states. Seemingly logical requirements can lead to illogical consequences. For instance, Montana's requirement for a flatter slope at a mineral extraction site can lead to more earth moving costs, more disruption of terrain, and greater reclamation costs in the end. Regulating agencies should investigate the effectiveness of compliance requirements of surrounding states and adopt those that do a better job of protecting both industry and the environment. Federal, state, and local regulating agencies should also attempt to make regulations consistent from agency to agency, and from the state to federal level.

Montana needs to carefully examine its tax laws to determine disincentives to industry and investment in the state. Once a concept is past the basic research stage, there can be barriers that would preclude a pilot plant or production facility from locating in Montana. The differences in tax rates from "research and development" (R&D) to "industrial equipment" may cause a business to locate production jobs outside the state. The lower tax rate for R&D equipment is an incentive for firms to locate in Montana. The state should consider other approaches that encourage investment and job creation. To encourage industries to stay in Montana and add value to raw resources, state taxes should be restructured to be consistent with encouraging long term research and added value, such as deductions for benchmark levels of value added or jobs created; earmarking additional dollars to industry-related research, etc. Pennsylvania uses a comparable value taxation approach that recognizes the financial benefit the state receives from people being gainfully employed. Based on a calculation that quantifies the benefit (reduced welfare costs, income tax revenues, etc.) the state allows companies to take a tax credit for each new full-time employee added to the payroll during a year.

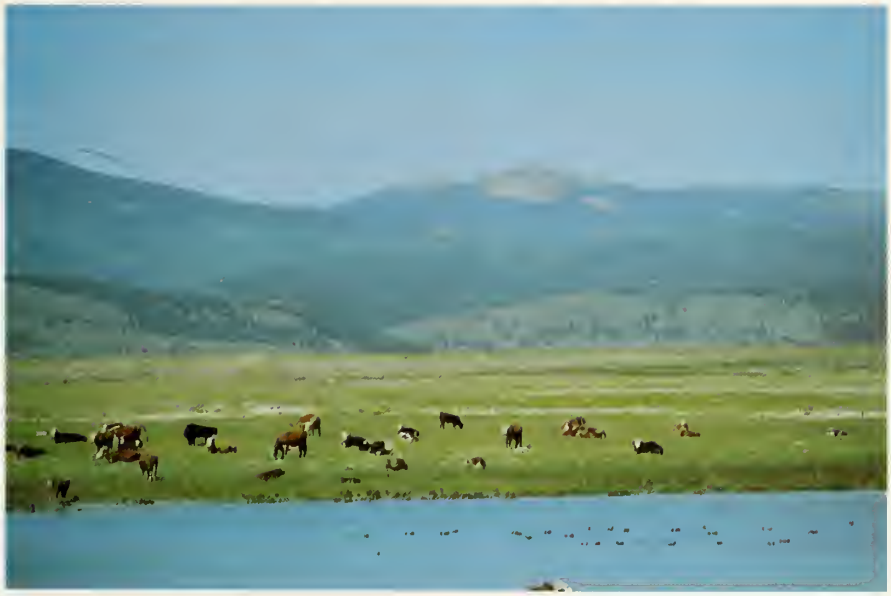

Photo courtesy of Montana Stockgrowers Association

Successful implementation of the Science and Technology Action Agenda depends on improved public education and awareness, adequate funding, and appropriate legislation.

Public Education and Awareness

While developing the Science and Technology Plan, the Montana Science and Technology Advisory Council and its consultants found that relatively few Montanans were well acquainted with the scope and implications of the scientific and technological advances that are changing the nature of our economy and propelling us into a global marketplace. At the same time, the Advisory Council found many examples of Montanans who are keeping pace with the changing world of science and technology — Montanans who are not only surviving, but thriving in the face of these new realities. We must help other Montanans understand what is happening and what they can do to adapt to the new technological economy and benefit from the opportunities it offers.

"Technology actually is reshaping every existing job and becoming a prerequisite for the formation and survival of most new enterprises."

■ ■ ■

We need to prepare the public for the new economic realities associated with a technological economy. Right now there is little evidence that the general public of Montana has an effective understanding of the significance of science and technology as they relate to the future of Montana's economy. Personal and public decisions all too often are based on outdated information and obsolete ways of doing things. The tendency is to think of new technology only as a basis for new jobs. Technology actually is reshaping every existing job and becoming a prerequisite for the formation and survival of most new enterprises.

Perhaps the most important step in implementing our carefully crafted Montana Science and Technology Action Agenda is to cultivate public awareness, acceptance, and support. Through public education and awareness activities, we can develop a shared new way of looking at Montana's economy and the significant contributions and potential of science and technology. The future of Montana demands public awareness and support of critical strategic science and technology issues. Successful implementation of our Science and Technology Agenda depends on the support of Montana people to transform it into a dynamic process.

A 32-member statewide steering committee of volunteers is designing the public education and awareness activity for the Montana Science and Technology Action Agenda. The committee includes representatives of universities, industry, broadcast media, advertising and public relations, labor organizations, telecommunications, public education, scientists, engineers, chambers of commerce, government, the MST Advisory Council, organizations, associations, and individuals. The steering committee is an extension of the Montana Science and Technology Advisory Council and works closely with the Council and with those involved in implementing other elements of the Agenda.

The public awareness campaign will use language and messages that make science and technology topics more accessible and less

intimidating to general audiences and to students. It will use a combination of direct contact and mass media approaches to help Montanans understand:

- the importance of math and science education at all levels;
- the nature of key science and technology advances that have significant impacts on living, working, and earning;
- what those impacts mean to the average individual;
- how specific Montanans are using new developments productively, for themselves and their neighbors; and
- the existence of specific institutional and personal resources in Montana that can help each Montanan succeed.

Funding

We project that full implementation of Montana's Science and Technology Action Agenda between 1993 and 2001 will cost approximately $585 million. Major components of that cost include:

- Montana Science and Technology Seed Capital
  $ 18 million state
  $125 million private;
- Special Research Centers (not including Biotechnology)
  $ 24 million state
  $ 75 million federal & private
  Center for Interfacial Microbial Process Engineering
  Center for Advanced Mineral Processing
  McLaughlin Research Institute
  Deaconess Research Institute;
- Biotechnology
  $ 40 million state
  $120 million federal & private
  Center of Excellence in Biotechnology;
- Basic Research Infrastructure
  $ 34 million state
  $100 million federal & private; and
- Focus Group Related Projects
  $ 24 million state
  $ 25 million federal & private.

Area	93-95	95-97	97-99	99-01	8 Yr. Total	Leverage Funds	Remarks
Seed Capital	8M		10M		18M	125M	1:1 match required (18M + 18M =36M); plus 2.5:1 match from equity, grants, etc. ($89M + 36M = $125M)
Special Research Centers	6M	6M	6M	6M	24M	75M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Biotechnology	10M	10M	10M	10M	40M	120M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Basic Research	10M	10M	7M	7M	34M	100M	3:1 leverage from federal programs, private corporations and foundations (leverage typically averages from 7:1 through 10:1)
Focus Group	8M	8M	4M	4M	24M	25M	1:1 leverage is anticipated from private fundings and possible federal match
Totals	42M	34M	37M	27M	140M	445M	

Legislation—1993 Session

- **— Seed capital funding bill (majority vote)**
- **— R & D and infrastructure funding bill (3/4 vote)**
- **— Establish Science and Technology Advisory Council as continuing policy development arm within Office of Governor supported by MSTA.**
- **— Redirect portion of Resource Indemnity Trust Tax into mining-related research**
- **— Harmonize Montana and USDA meat inspection standards**
- **— Establish "one-stop permitting" within state government**
- **— Make science and technology fee waivers as a priority within Montana University System**

A commitment from Montana for $140 million over four biennia will generate approximately $445 million in matching funds from federal and private sources. In addition, the proposed technology transfer position within the Office of the Commissioner of Higher Education will generate income, some of which will be returned to the state through sales of intellectual property, license agreements, etc.

"To enhance economic development through science and technology, Montana must demonstrate a sincere long-term commitment to building the state's scientific infrastructure."

■ ■ ■

The $250 million fund-raising campaign proposed in the June 1991 Science and Technology Policy and Plan will begin when this Action Agenda is adopted by the state and state funds are committed for its implementation.

Legislation

Most of the enabling legislation to encourage science and technology in Montana is already in place. What is needed now is legislation to enable funding for the state-supported portions of the plan. To enhance economic development through science and technology, Montana must demonstrate a sincere long-term commitment to building the state's scientific infrastructure.

The components of our legislative package are:

- Establish the Montana Science and Technology Advisory Council as the continuing policy development arm of the state, within the Office of the Governor, to carry out the activities defined in this agenda;
- Allocate $122 million from the Permanent Coal Trust as the State of Montana's commitment over the four biennia 1993 - 2001. An appropriation from the Permanent Coal Trust will require a 3/4 vote of both legislative houses. The intent is to appropriate these monies to the Science and Technology Fund that will allow the Montana Science and Technology Development Board to either grant them as needed or require payback, wherever a possibility of payback exists;
- Allocate $18 million for seed capital and early stage development between 1993 and 2001, under the existing statutory requirements of the Montana Science and Technology Alliance;
- Redirect a portion of the Resource Indemnity Trust Tax to fund research into minerals extraction, processing, remediation, and recycling;
- Harmonize Montana's standards with intergovernmental standards and inspections;
- Establish one-stop permitting for industry; and
- Make university fee waivers more available for science and technology in order to make Montana institutions more competitive in recruiting well qualified graduate students.

Summary

This Action Agenda is a challenge. It's an expensive challenge. The question we face is whether we in fact rise to today's test to create a tomorrow that well serves our state and its future generations. The Montana Science and Technology Advisory Council and the hundreds of Montanans who worked to determine how best to invest in ourselves urge your support. Technology is moving so fast that every year of inaction takes five years to replace. Not acting now will put Montana hopelessly behind. The expense of that is truly much more than we can afford.

Night shot of a dragline at Rosebud Mine.

R. Webster/Photo courtesy of Western SynCoal Company

Following are summaries of the reports submitted by the eight focus groups. The Montana Science and Technology Action Agenda includes only those elements of the focus group reports that best serve the Montana taxpayer. It does not include all the needs identified by these grassroots, industry groups. *Copies of the unabridged focus group reports are available through the Montana Science and Technology Alliance.*

Bryant Photographics/Photo courtesy of Ribi ImmunoChem Research, Inc.

Production technician with melanoma "cell factory" (cell-culture device) at Ribi Immunochem Research, Inc.

Colstrip generating units in an electrical storm.

Focus Group Members

Choir: John Morse
Zenchiku Land and Livestock
Dillan

Peter Burfening
Montono Stote University
Bazeman

Kim Enkerud
Mantana Stackgrawers
Helena

Jae Gutkoski
Mantana Wildlife Federatian
Bazeman

Kim Hager
Agri-Basics
Belgrade

Delares Harrer
Women Involved in Form Ecanamics
Fart Bentan

Sue Huls
Mantana Pork Praducers
Bazeman

Virginio Jacksan
Mantana Cattlewamen
Horrisan

Cark Martensen
Mantana Farm Bureau
Heleno

John Paugh
Mantana Waol Grawers
Bozemon

Gory Ruff
Mantana Cattlefeeders
Custer

Diono Scallard
Mantana Veterinary Medicol Ass'n
Absarakee

Brent Silcox
Mantana Beef Cauncil
Helena

C.A. Speer
Montona Stote University
Bazeman

Senatar Gerry Devlin
Terry

Senotor Greg Jergesen
Chinoak

Representotive Rager Debruycker
Flawerree

Representative Dan Steppler
Bracktan

Background

Agriculture is Montana's largest economic sector, with animal agriculture contributing $863,679,000 annually to the economy. But, from 1984 to 1990 the number of livestock operations decreased 19 percent, from 24,000 to 20,200. Cattlemen, with an average age of 55, make up the oldest sector of U.S. agriculture. Montana's beef production industry is mature; and the pork production business is producing more than processors can handle. This, coupled with heightened consumer diet and health awareness, changing consumer preferences, and competitive demands on Montana resources, will make the next decade most challenging.

Diverse groups pursuing individual agendas will increasingly affect our industry. Animal rights activists will label many established practices "inhumane." Environmental activists will influence the way we manage our environment. The concept of multiple use of public lands will be challenged by single use advocates. "Livestock free by '93" is a common slogan of such interests.

Needs and Interests

To survive and prosper in the 21st century, Montana's animal agriculture industry must become more competitive, add more value in Montana, and take advantage of advances in science and technology specific to our industry. Our needs and interests focus on changes, advances, research, and value-added ideas that enable present and future generations to "stay on the land."

Efficiency Issues

Competing demands: Competing demands for basic resources re-emphasize the need for research on more efficient use of our resources. Concerns about water quality and availability, riparian areas, livestock and big-game conflicts, endangered species, etc., are leading federal land management agencies and state government to play a greater role in determining the use of Montana's rangelands. Government could best serve our interests by acting as a catalyst to bring user groups together to improve cooperation and enable well-considered environmental management approaches, such as watershed management.We need to demonstrate the environmental as well as economic value of Montana ranches; otherwise, Montana rangeland could end up a "concrete" landscape.

Communication/information flow: Technological innovations such as the computer modem, fax machine, satellite dish, and fiber optic technology are redefining methods of gathering and disseminating information. These advances are causing a re-evaluation of cooperative extension services and information-delivery systems. Basic communication between industry groups, government, the University System, and the various research groups must be improved. Industry must communicate its research priorities to researchers.

Mortality/morbidity: The cost of mortality and morbidity associated with stress and disease is one of the largest contributors to efficiency loss in animal production. Modern animal agriculture must continue to emphasize disease prevention rather than treatment.

Research funding: Research and the transfer of technology to industry require improved funding of the Montana University System. New, different, or alternative revenue may be the best answer. Researchers and universities involved with technology transfer should receive some financial incentive to advance worthwhile projects based on emerging technology. UniversitySystem research dollars should be allocated equitably, reflecting the proportionate contribution to the state's gross agricultural receipts by animal and plant agriculture.

Value-Added Opportunities

The concept of "value adding" is important to the long-term viability of our industry. But, past attempts to resurrect failed packing facilities indicate the difficulty with traditional approaches to value adding. Nationwide, packing plants and feed lots are under-utilized. By placing emphasis on "taste", marbling, and over-all carcass leanness, the "certified Angus beef" program has been extremely successful. The American Angus

Association is the only national breed organization with a structured sire evaluation program to evaluate progeny carcass characteristics, and end product value. As the supply of choice grade beef decreases, the demand for certified Angus beef intensifies. There is only one small CAB plant located in the West. Not only that, the largest of the major packing companies recently obtained CAB status. Montana might consider developing a small to medium sized packing facility specializing in production of certified Angus beef and other high quality beef, positioned for both domestic and export markets.

The livestock industry is "mature" and in danger of losing further market share, so careful attention to the "new market" and market signals will be important. Although the national trend appears to be toward "lean" cattle, U.S. high-quality beef exports have increased 700% in the last decade and exceeded $1.2 billion in exports to Japan alone, reflecting the industry's long devotion to achieving "free trade", and "market access." U. S. Meat Export Federation CEO Phillip Seng explains, "The U.S. industry's successful penetration of the Japanese market was underpinned by patience coupled with four simple steps often ignored by companies unfamiliar with Japan's culture: learning the Japanese market, cultivating alliances with consumers and business leaders, setting realistic expectations, and delivering a quality product tailored to the Japanese."

A more cooperative attitude between government and industry could help the animal agriculture industry take advantage of a significant opportunity in meat inspection to facilitate the interstate flow of Montana products. Montana must harmonize its meat inspection with USDA standards. There must be a process to allow interstate flow of meat products produced in Montana plants meeting USDA standards, but Montana-inspected rather than USDA-inspected.

Montana has a reputation of exporting some of the best breeding stock in the world. Value adding can mean developing better breeding stock through genetic manipulation or even genetic engineering. Value-added might also mean

Courtesy of Montana Stockgrowers Association

optimizing livestock, wildlife, fisheries, and water resources to realize more dollars from an economic unit. This could be done through leasing hunting and fishing rights, in conjunction with livestock operations. Other value-added opportunities for Montana animal agriculture might include dude ranching, fish farming, and game farming.

We can begin adding value by improving utilization of our own basic resources, including rangeland resources. We need to concentrate on what we have always done best. For example, performance testing, as we know it today, began in Montana. Montana is the nation's leading producer of quality seed stock. Because of the quality of our environment and livestock base, Montana is well positioned as we move into the 21st century.

Alternative Uses for Raw Materials and Products

There may be substantial economic benefit associated with game farming, including large animals, game birds, and fish farming. But, there is also significant risk of transmitting disease to important Montana wild game resources, domestic livestock, and the human population, as well. The American Association of Wildlife Veterinarians expressed its concern to the Animal and Plant Health Inspection Service (APHIS) over the alarming number of diagnoses of bovine tuberculosis in captive elk and deer and other game ranch ungulates. There is also a danger of the spread of brucellosis from Yellowstone Park bison to domestic livestock.

Relevant In-State Research, Applications Capabilities, and Needs

The Natural Resource curriculum at MSU, combining instruction in renewable natural resources and livestock/wildlife management, is a strong step in the right direction. This curriculum will focus on science and business aspects of natural resource management relating to rangeland, livestock, and wildlife. However, we also need to fund and expand research to answer questions about degradation of natural resources and sustainability of agricultural systems.

Montana's biggest crop is grass. Two-thirds of the state is rangeland, most of it privately owned. Rangeland nourishes not only livestock, but also wildlife. Rangeland sustains the watershed by protecting the soil from erosion, and safeguards water supplies for domestic and industrial use. Because of our industry's dependence on natural resources, we must continue to emphasize basic resource research with emphasis on better range management that improves rangelands and their use.

There are few companies in Montana involved in animal biotechnology research and development. The Animal and Range Sciences Department and the Department of Veterinary Molecular Biology in MSU's College of Agriculture/Agricultural Experiment Station provide nearly all of our animal biotechnology. Obviously, Montana does not have the critical mass of researchers to address all the biotechnological needs listed. But, we can start by focusing research and development efforts on our areas of strength. Research faculty in Veterinary Molecular Biology (VMB) at MSU have nationally-funded research programs making progress in the basic molecular biology and genetics of animal immune systems, as well as in the ability to manipulate and identify components of microorganisms that cause disease. They will continue to be actively involved in the development of vaccines and novel non-vaccine methods of preventing disease, and the highly specific and sensitive diagnosis of disease, as well as the animal genes responsible for disease resistance. Montana needs the following biotechnological research to benefit animal agriculture:

- Basic information concerning animal biology, emphasizing appetite and diet, stress and disease;
- Transgenic technology;
- Early pregnancy tests;
- Methods of modifying animal products for fat and other characteristics;
- Inexpensive, easily used diagnostic tests, chemoprophylactics, chemotherapeutics, and vaccines;
- Transcription factors and other regulators of gene expression;
- Regulation of cellular functions (growth factors, transcription factors and second messenger systems);
- Nutrient requirements to produce desirable food qualities;
- Gene maps of animal species and of disease-causing microorganisms;
- Biological and genetic enhancement of animal efficiency; and
- Improvement of nutritional quality, composition and safety of animal products.

External Support Resources

Education: These days we are consistently reminded to "Think Globally." According to U.S. Ambassador Mike Mansfield, "International education in fostering international trade activity is...one of the most important factors in achieving a better understanding of different cultures." Sitka Karahan, Director of International Studies at Montana State University College of Business adds, "You cannot have true education without an understanding of international and global issues. We do not have to operate internationally, but we have to think internationally. Every subject should have an international component or global perspective."

The U.S. is the only industrialized nation among all the highly developed nations that does not re-

"You cannot have true education without an understanding of international and global issues. We do not have to operate internationally, but we have to think internationally..."

quire languages to be taught at every level. Livestock production, beef production, and related genetic activities are quietly becoming the first freely traded commodity sector in the world. Montana is uniquely situated to supply high quality beef, genetics, and specific, related biotechnology to newly emerging markets. To prepare the next generation to compete and keep pace with globalization of industry, Montana education, including agriculture education such as the Animal Science Department at MSU, must shift away from strong production emphasis and broaden curricula to include language and culture.

Action Agenda

1. Upgrade the Cooperative Extension Service by adding an extension veterinarian and making information available via easily-accessible electronic media. The "extension or liaison" veterinarian in the College of Agriculture would disseminate information about advances, new practices, and alternative business opportunities in animal health. This position would not compete with private veterinary practitioners, but would enhance the client-veterinarian relationship.
2. Restructure the various university "advisory groups" to create effective advocacy groups to improve priorities and funding of research projects. While the universities have traditionally sought industry "ideas and support," this has typically been more of an approval seeking process than a process of uncovering industry's research needs.
3. Focus research on optimizing livestock production in a rangeland setting. Considerable research is still needed on animal health, reproductive biology, genetics and nutrition. We also need to research individual animal performance and the enterprise unit itself to optimize livestock production in a rangeland setting. Research must clearly focus on livestock and wildlife as harvesters of solar energy, converting that energy into a form of product useful to humankind. Our primary focus must be the rangeland livestock/wildlife co-relationship and the optimization of economic return without degradation of the eco-system. In fact, we should also be working to show how livestock and/or wildlife can improve the rangeland eco-system. Emphasis should be on sustainability — management practices that are economically profitable, environmentally sound, and socially acceptable, over time.
4. Improve the efficiency of animal agriculture through biotechnology. Biotechnology continually refines and perfects agricultural practices. Although each animal generation or season may result in only a modest upgrading, improvement accumulates with each cycle, in a fashion similar to compound interest. Biotechnological research in modern genetics, physiology, and animal health offers outstanding opportunities to sustain and improve Montana animal agriculture.
5. Protect domestic livestock and big-game species from possible infection by big-game farming activities. More research into the transmission of disease among wild and domestic animals and humans is important.
6. Make university fee waivers more available for science and technology so we can compete in recruiting high quality graduate students.
7. Fund university animal sciences programs proportionately with the plant sciences in terms of personnel and facilities based on the total cash receipts of livestock and crops (54% and 46% respectively).
8. Establish a business incubator to help deliver technology developed in Montana to the market and enable entrepreneurs to access highly qualified business experts, scientists, and financial experts in a highly productive, creative environment.
9. Harmonize Montana's meat inspection with USDA standards and create a process to allow interstate flow of meat products produced in Montana plants meeting USDA standards, but Montana-inspected rather than USDA-inspected.
10. Expand K-16 curricula to include international education, computer literacy, and language training at every grade level.
11. Establish cross-university curricula.

"Emphasis should be on sustainability — management practices that are economically profitable, environmentally sound, and socially acceptable, over time."

Focus Group Members

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Background

Agriculture is Montana's number one industry with more than $1.5 billion in 1990 cash receipts. While the majority (54%) of cash receipts is from livestock, a successful cow-calf operation requires plants to feed them. Major acreage crops with potential for added value and interest in expanding markets are wheat, barley, and alfalfa hay. Minor acreage crops with potential for significant added value include canola, safflower, seed potatoes, oats, mint, sugar beets, alfalfa, grass seed, and turfgrass. New and alternative crops with unknown potential include amaranth, buckwheat, medics, medicinal plants, and others. Noxious weeds represent another basic material.

Needs and Interests

Plant agriculture's greatest need is to increase profitability in a rapidly changing world marketplace, while sustaining renewable productivity. We need to identify cropping systems and best management practices that limit environmental impacts and improve profit.

Efficiency Issues

Weather is a constant challenge to producers. Since 1984, major grain producing areas have experienced four disastrous drought years. The Eastern third of the state has faced drought eight of the last ten years. However, Montana's agriculturists have already identified the desirable, unique characteristics of crops that can be grown here and are developing them for market. Montana winter, spring, and durum wheats are known for their quality. Our malting barley is highly regarded in the brewing industry, providing high average premium over feed barley. Montana is becoming known as a producer of high quality hay. Our calves are highly regarded by stocker operations thanks, in part, to the plants they and their mothers eat here. Weather conditions that reduce disease pressure make Montana a significant seed potato producer, and a potentially significant mint seed stock producer.

Montana's sparse population creates a lack of local demand for finished products, so we are an "exporting" state. Montana's distance from population centers and major processing plants makes us shippers of bulk commodities, rather than refined products. Freight to an export facility in Portland costs roughly 20% of the Montana value of that wheat, in part because our only major railroad has little competition.

We need technology appropriate to most Montana agriculture — large areas and large machines. Technology appropriate to "niche producers" and processes is also needed. Appropriate technology needs to be brought on line quickly. It takes a long time and a lot of money to bring a new crop product to the marketplace. This can be very troublesome for minor and niche crops because the volume of business doesn't justify the testing required to allow labelling on those crops. This issue will become more important as the science of "bio-engineering" matures and brings new possibilities.

Value-Added Opportunities

While we probably won't see major construction of a traditional user of Montana's raw products, such as a large flour mill, there is significant potential for facilities that can fill special niches or have multiple co-products. Several small flour mills and bakeries produce wonderful flour and bread products with our special wheats. We also have about half a dozen micro-breweries. A proposed ethanol plant will extract vital gluten from high protein wheats, producing carbon dioxide, distillers dried grains, electricity, and ethanol, and then supply heat for green houses. And, we are finding new uses for refined/processed oats.

By locating processing as close as possible to the raw material source, plant agriculture has great potential to add value to Montana plant products before they leave the state, especially products specifically designed to be made from crops where Montana has a production advantage. Adding value to raw products can help mitigate Montana's transportation disadvantages by reducing the cost of freight as a percentage of total value.

Reutilization of Wastes

Montana produces 200 to 250 million bushels of wheat and barley per year, resulting in around 10

million tons of straw. While most of that straw stays on the land to help control erosion and maintain tilth, there are possibilities for using some of this straw as more than just bedding or feedstuff for livestock. Waste products from smaller plants could substitute for some wood products, relieving pressure on our forests.

Alternative Uses for Raw Materials and Products

The most exciting prospects for value-adding require additional research:

- Some plants, including alfalfa, oats, and canola, may be well suited for the production of high-value specific compounds or oils justifying locating processing plants in Montana;
- Use of plant products for "biodegradable" product packaging could relieve pressure on the nation's landfills;
- Biotechnology could control or mitigate weeds, insects, diseases, and other pests and produce better strains of traditional plants and plants new to Montana;
- Research into traditional crops, minor and niche crops, and new management systems may make agriculture better and less expensive at the same time; and
- Allelopathic traits could be incorporated into desirable plants.

Relevant In-State Research, Applications Capabilities, and Needs

Montana has a 100-year history of agricultural research through the Montana Agricultural Experiment Station (MAES) and MSU. Research centers in Bozeman, Corvallis, Conrad, Creston (Kalispell), Havre, Huntley, Moccasin, and Sidney enable plant and soil scientists to research in varied environments — important for developing plant varieties with improved yield and/or end-use properties. The Plant Growth Center at MSU is a state-of-the-art center for plant research. A focus of excellence in plant biosciences and biotechnology consisting of nine MSU scientists and one UM scientist is available for biotechnological manipulation of wheat, barley, and alfalfa as well as canola, safflower, and potato.

MSU is also the home of an International Program for New Crops, Products, and Markets, organized to create, collect, and evaluate new crops, products, and markets; facilitate research and development; and inform the public. There is also a center for sustainable agriculture research at MSU. There are strong linkages between MSU, state agencies, and in-state organizations, e.g. AERO, researching methods to sustain agricultural production while reducing inputs. USDA/ARS scientists conduct plant agriculture research in Bozeman, Miles City, and Sidney. Soil Conservation Service scientists are located throughout the state, and the Bridger Plant Material Center is an important resource for new plant material.

Compared to just 15 years ago, today's capacity for genetic manipulation of plants is astounding. Genes from virtually any organism can be transferred into crop species. Plant breeders are using molecular genetic markers to improve the efficiency and precision of plants. Montana has an excellent cadre of plant scientists using molecular tools in plant manipulation programs. We have the capacity in Montana to modify wheat, barley, alfalfa, potato, canola, and safflower through molecular technology.

Photo courtesy of Montana Grain Growers Association

External Support Resources

Research Programs: Research programs in Montana are competitive, and can be strengthened with in-state support to obtain greater federal funding. While there is very little private industry conducting research and development for improving plant agriculture, there is substantial basic and applied plant research in the Montana University System (especially MSU), and the Montana Agricultural Experiment Station. USDA/ARS scientists in Bozeman, Miles City, and Sidney are an additional resource. There is a long history of interaction between MSU scientists and USDA/ARS scientists in conducting research to improve plant agriculture.

"Plant agriculture's greatest need is to increase profitability in a rapidly changing world marketplace, while sustaining renewable productivity."

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Plant scientists at MSU and UM have established records of securing competitively awarded grants through federal agencies such as USDA and NSF. Since 1978, MSU has received significant funding from NSF-EPSCoR. There is potential for significant increases in funding from federal grant agencies through EPSCoR-type programs in NIH, USDA, EPA, NASA, DOE, and DOD.

Public schools and universities: The public school systems in this state do a very good job of educating our young people. Significant curricula in many schools help provide a basis for further technical education. The university system also has many good programs and turns out well educated individuals. While out of the scope of this focus group's purview, there is concern about spending limited education dollars trying to coordinate the numerous institutions in this state of less than one million people.

Industries: There is little research and development by plant agriculture industries in Montana (Monsanto, DuPont, or Pioneer Hi-Bred Int.). There is significant potential to increase industry use of Montana's plant agriculture products. For example, several industrial sources are accumulating capital to construct a large ethanol production plant in Great Falls. Other examples include processing plants for safflower in Culbertson, canola in Butte, oats in Missoula, and barley in Dillon. There is also considerable potential for increased industry support for Montana R&D through limited contract research.

Government: Government policy takes various forms that affect the economic climate. In turn, the economic climate plays a major role in development and growth. Montana needs to carefully examine its tax laws and business regulations to determine disincentives to agribusiness and agricultural industry investment in the state. While it is beyond the scope of this committee to identify and analyze the effect of all government policies affecting Montana's economy, a variety of taxes, regulations, etc. are viewed as disincentives to economic development.

State support for research and development: The Montana Wheat and Barley Committee and the Alfalfa Seed Committee generate revenue for research and marketing via assessments on products produced on the farm. Assessments on fertilizer also provide funds for soil fertility research and education through the Fertilizer Advisory Committee; and the vehicle weed fee provides funding through the Noxious Weed Trust Fund for research and control of noxious weeds.

Action Agenda:

1. Research plants with specific traits. For example:

- Wheat, barley, and sugar beet varieties precisely developed for ethanol production and other products;
- Specific barley varieties for human food, animal feed and malt;
- Wheat and barley varieties developed for alternative products, e.g., specific industrial uses;
- Alfalfa varieties that produce pharmaceuticals or cosmetic compounds;
- Precisely defined oils in canola and safflower;

- Turfgrass varieties for precision management;
- Riparian plants that could be used to better stabilize stream banks and provide food and cover for wildlife; and
- Plant varieties targeted for certain management systems, including livestock production, wildlife production, reclamation of disturbed or degraded (e.g., saline) soils and soil stabilization.

2. Take advantage of environmental issues causing changes in other states as well as Montana. For example, water availability and agrichemical concerns are limiting alfalfa seed production in California. Montana should be able to take advantage of this in the 1990s.
3. Concentrate research on improved agronomics and improved uses for traditional crops, including bio-replacements for fats, plastics, insulation, construction materials, etc.
4. Study indigenous plants for medicinal or industrial uses and as possible hosts for production of useful and profitable substances.
5. Through the Plant Growth/Quarantine Center at MSU, investigate useful traits in plants that do not currently grow here.
6. Base policy decisions regarding new products and technology and their availability to the public on good science rather than emotion.
7. Aggressively pursue federal funding for the new Biosciences Building attached to the Plant Growth Center at MSU to significantly expand our research capabilities in plant agriculture, including biocontrol agents, end-use improvements of crops, and improved new and existing crops.
8. Demonstrate an increased commitment to building the state's scientific infrastructure through increased matching funds support from the Montana legislature. The $5.1 million appropriated by the 1991 legislative session had a payback requirement, inappropriate for funding to build scientific infrastructures.
9. Pursue research and development contracts between the state's research community (e.g., its universities) and private industry. Monitor activity to ensure that contracts are in the best interest of Montana.
10. Increase state funding for long-term research and development efforts.
11. Encourage interdisciplinary research and development teams via appropriate funding "carrots." The USDA is committed to accelerating research to increase the use of agricultural commodities in industrial products such as starch-based packaging and polymers or biotechnological manipulations to turn plants into factories producing expensive compounds used in the pharmaceutical or cosmetic industry. Montana has numerous potential outlets for its two largest plant commodities, wheat and barley, as well as alternative uses of wheat and barley starch. We need funding initiatives to develop increased research and development efforts between state scientists and appropriate industries for interdisciplinary research.

"...there is significant potential for facilities that can fill special niches or have multiple co-products."

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Communications and Manufacturing Technology and Processes

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Background

Communications: Most Montana communities have state-of-the-art telecommunications systems with a network of fiber optic transmission systems spreading to connect them. Companies are working to provide two-way interactive video services to Montana schools through fiber optics, compressed video, and other technologies. We have microwave radio systems that carry information between fixed locations, and very small satellite systems that carry data via rooftop satellite dishes. Satellite dishes are being installed at schools and libraries across the state to provide access to a growing number of educational programs. Within the last five years, cellular telephone companies have built cellular systems in most large and medium-sized communities in Montana.

U S WEST Communications is upgrading 112 smaller communities to digital switching technology and connecting them via digital transmission facilities, including fiber optic cables. TCI Cable is deploying fiber optic cabling throughout communities to increase channels available. TCI also plans to use a fiber backbone system with a new radio technology to offer telephone service.

Manufacturing: There were about 21,700 manufacturing jobs in Montana in 1991. The percentage of Montana workers employed in manufacturing jobs has dropped from almost 14 percent of all non-agricultural jobs to about 7 percent in 1991. This downward trend is projected to continue through the 1990s. Much of the decline is related to the closure of major operations in primary metals refining, lumbering, and food processing. The overall composition of manufacturing firms has also changed. Most Montana manufacturing operations are relatively small, employing fewer than 100 workers.

Needs and Interests

Montana's telecommunications industry is interested in fostering competition while preserving widely-available, affordable basic telephone service.

Telecommunications also plays a catalytic role in rural economic development. Unlike other rural development strategies that target specific industries or regions, enhanced telecommunications can help a broad array of industries in various rural regions.

We are also interested in creating jobs in Montana for our children. About 8,000 students graduate from Montana high schools each year. These people, plus others moving to Montana or displaced from other industries, will produce an abundant, available labor pool. The Montana Department of Labor projects the number of manufacturing jobs will grow to 23,100 by 1997, but the percentage of non-agriculture total employment will continue to decline. To turn around the trend and increase manufacturing jobs, we must set a target that forces us to focus our efforts rather than meekly accepting extrapolations of past trends.

Efficiency Issues

Easy access to information and available services: Manufacturers need easy access to information and services. Automated summaries of daily government contract bid lists and other research or requests for proposals could help businesses.

Skilled workers: There is a critical need to help business owners and managers understand and implement modern manufacturing methods and systems to increase productivity and improve quality while reducing costs. We need engineers and machinists; welders and computer programmers; quality assurance specialists and "thinking operators." We also need on-the-job skills training and continual education and retraining.

Maximizing productivity: The relatively small scale of most Montana manufacturers means information sharing and services must be packaged and tailored to address the special characteristics of small-scale operations. Small-scale manufacturers need to find ways to gain larger-scale leverage through cooperation and coordination. Much of this might be accomplished through networking, both physical and electronic.

Shipping/Transportation: Two-day guaranteed delivery to West Coast markets is frequently required to meet "Just in Time" supplier commitments. Without this level of transportation, contracts are lost.

Reducing barriers to success: There are many governmental barriers to success: fragmentation or lack of coordination; confusion about how to access information or assistance; multiple points of entry with no clear connectivity; and a tax structure on manufacturing equipment and worker's compensation/unemployment programs that make Montana uncompetitive. Taxes on manufacturing equipment (personal property tax) create a cost disadvantage. Montana should consider other approaches that encourage investment and job creation. Pennsylvania uses a comparable value taxation approach that allows companies to take a tax credit for each new full-time employee added to the payroll during a year.

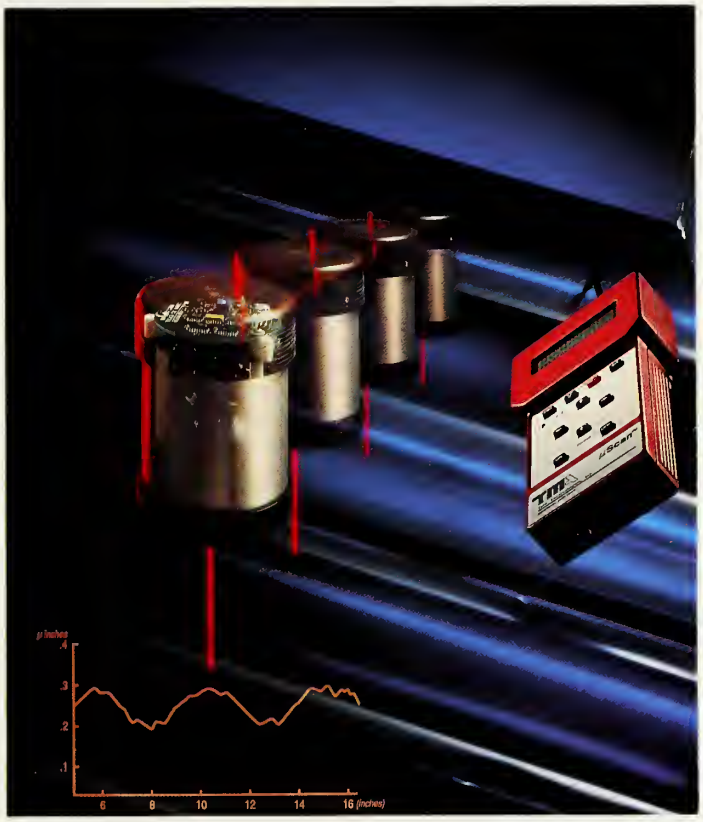
Technology Deployment: It often takes 25 to 75 years for technology to be adopted by 90 percent of the marketplace. Finding ways to speed the process is critical to Montana. We need to make business aware of available resources and find ways to strengthen their ability to incorporate new technologies into their operations — for instance, timely summaries of NASA technologies releases and National Institute of Standards and Technologies white papers.

Value-Added Opportunities

The "value-added" concept is inherently a marketing strategy driven by a manufacturing process. Taking advantage of opportunities for value adding will require a nurturing environment and stronger public/private partnerships. Developing partnerships and consortia to handle multiple levels of the manufacturing process can enhance the strength of the overall manufacturing sector, maximizing jobs and value-added margins.

The Montana Indian Manufacturers Network and other networks should identify fabrication and supply requirements of manufacturers in the state, communicate these needs with potential suppliers, and facilitate collaborative efforts to develop more vertical value-added manufacturing within the state.

Montana's interstate highway system makes us a good candidate for in-route value-added opportunities. Aerospace and other large industries have been using this process of assembling a product in-route to its final destination.



Wilke Photographics/Photo courtesy of TMA Technologies, Inc.

Photograph of the TMA µScan™, as appearing on the cover of a major trade magazine, serving the industrial measurement market with accompanying feature article on TMA equipment.

Reutilization of Wastes

Manufacturing produces waste. Yet, one manu-facturer's waste can provide raw resource for another manufacturer's product. Waste-management issues themselves provide additional opportunities for manufacturers.

> *"The percentage of Montana workers employed in manufacturing jobs has dropped from almost 14 percent of all non-agricultural jobs to about 7 percent in 1991."*
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Relevant In-state Research, Application Capabilities, and Needs

Several Montana institutions perform research relevant to the needs of communications and manufacturing technologies and processes, and have the capability to meet the needs of the communications and manufacturing industries:

- The Industrial Engineering Department at MSU can lead the way in training engineers for manufacturing positions. University business and other engineering programs should provide more information on manufacturing concepts such as Just In Time delivery, statistical process control, and other quality issues associated with world-class manufacturing;
- The University Technical Assistance Program matches technology with business interests. There are myriad other resources available through Montana university units, federal laboratories, and private organizations;
- The Montana Entrepreneurship Center identifies resources within the university system that can provide assistance and expertise to Montana business people. The concept could be expanded to include other public sector resources, e.g., Department of Labor, etc;
- The new MSU Engineering and Physical Science facility will include a computer-integrated manufacturing lab and other resources that could address many important needs. The lab, when properly equipped, could allow industry to try out technologies, and allow private firms access to equipment for small production runs; and
- MSU's Department of Agriculture and Technology Education is developing ways to incorporate practical technology and production education into classroom situations.

"The 'value-added' concept is inherently a marketing strategy driven by a manufacturing process."

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External Support Resources

Transportation: In a global marketplace, Montana is geographically no more remote than Taiwan or Italy. Transportation, a key issue for exporting manufactured goods, should improve over the next several years as efforts to enhance Canada-U.S.-Mexico trade result in improved transportation routes through Montana.

Education: Educators need to understand and convey the concept of students becoming "producers" of goods and services as well as "consumers." There should be more and better high school business and economics classes as an integral part of the curriculum. Business professionals could enhance these educational offerings, helping students understand work-place values such as productive work habits, ethics, reliability, etc.

Action Agenda

1. Create a nonprofit institute to address the manufacturing concerns outlined in this report. The institute would connect Montana manufacturers and people needing manufacturing work; provide networking with existing organizations; coordinate existing government, university, and private sector programs; initiate programs about issues affecting manufacturing competitiveness; facilitate communications and networking to connect Montana's industry with leading edge developments; identify industry-specific technical assistance and provide direction to resources; and connect manufacturers with scientific and technical resources.
2. Provide industry-specific, accredited, skill-related, life-long learning and continuing education to workers at places and times convenient to workers. Use National Technology University or other satellite delivery and teleconferencing in public school or public library distance learning facilities after hours.
3. Institute broad transferability of course credits among all units of the University System and other training and educational institutions.
4. Enhance the flexibility of vo-tech education/training to respond to the shortened product cycle for goods and services.
5. Educate Montana manufacturers about the need for, availability, and value of worker skill training and other personnel development opportunities.
6. Ensure equity between public and private training and service providers. Many manufacturers and other private firms market their expertise in manufacturing areas. They should be encouraged and not unfairly affected by public programs.
7. Emphasize skill training and modern manufacturing issues in high school and vo-tech education. Expand computer, math,

science, communications, reading, and real-life problem solving skills throughout K-12 education.

8. Promote more access to computer technologies such as Big Sky Telegraph, METNET, and EDUNET to expand teacher and student use and understanding of information sharing, information literacy, critical thinking skills, and the tools of the work place.

9. Develop a computerized manufacturers directory database with bulletin board or key-search capabilities detailing the products of the firm and its processing capabilities.

10. Build and document a network of Montana manufacturers certified to international ISO-9000 quality standards. In addition to enhancing the individual competitiveness of each firm, the collective certification to these standards would demonstrate an enhanced manufacturing capacity in the state.

11. Facilitate vertical manufacturing integration within the state through expansion of existing businesses or networking of compatible firms.

12. Enhance technology development and intellectual property transfer from the university sector to private markets. Establish a clear process that encourages university faculty to pursue technological solutions that may have commercial value, and that makes technologies available to commercialization as quickly as possible. The procedures should be consistent among the units of the University System.

13. Strengthen state and university support for access to technical assistance. Make university equipment and services available for critical industry test/instrumentation requirements.

14. Forge cooperative efforts to solve major issues. Identify specific issues of state concern and proactively build private/public consortia to address them.

15. Examine the feasibility of coordinated shipping and purchasing through central or regional clearinghouses.TheMontana Competitiveness Council may be a natural leader in this activity. Perhaps the Port of Butte could provide scheduling coordination to expedite shipping.

16. Encourage experts in the public sector to be more involved in private sector ventures, boards of directors, and other advisory capacities for Montana businesses. Teleconferencing would expand the ability to include these people, save money, and make better use of everyone's time.

"Educators need to understand and convey the concept of students becoming 'producers' of goods and services as well as 'consumers'."

■ ■ ■

Focus Group Members

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Background

Energy resources have played an important part in Montana history since coal powered the railroads and mines that developed Montana industry. Later, as coal faded from view, hydropower, natural gas, and oil came to the fore.

Montana's estimated coal reserves of 120 billion short tons are greater by far than any other state. Montana's coal production increased from 30 million tons in 1980 to 38 million tons in 1990. Montana ranks fifth in the ten-state northwest region in crude oil reserves and fourth in natural gas reserves. A brief boom in oil and gas drilling occurred in the early 1980s as crude oil prices around the world skyrocketed. But the increase in drilling was short-lived; crude oil prices fell. Labor income and employment fell, too. In 1981, Montana employment in oil and gas exploration exceeded 7,000 workers, but now stands at 2,100. And, despite increases in coal production, employment and labor earnings are also declining in that sector. Montana's coal mining employment dropped by 17% in the 1980s despite a 26 percent increase in state coal production. Coal producers have simultaneously expanded production and decreased employment through labor-saving technologies. Labor income received by coal mining workers dropped 25 percent in the last five years.

In Montana, the mining and use of coal generates dollars for the Permanent Coal Trust Fund and has the potential to redevelop our infrastructure, provide jobs for Montana citizens, and act as a cushioning agent well into the future.

Needs and Interests

People are demanding more high-quality, cost-effective energy products at a reasonable price; and they are concerned about how products are produced and delivered. With concerns about water quality, appropriate uses of limited water supplies, and the unavailability of sites for new dams, the growing demand for electricity is being met more often by thermal power, again powered by vast Montana coal reserves. Virtually every future energy scenario developed by the U.S. Department of Energy and other forecasters involves increasing use of coal. We need to focus on efficient, clean, cost-effective methods of extracting and adding value to Montana coal.

"Trade secrets" and other competitive issues limit open communication between companies on new technology and reclamation processes that can help satisfy public concerns. Networking within the industry is an important need in energy resources.

Our overriding interest is to explore ways to apply science and technology to solve energy issues, safely developing and adding value to Montana's energy resources while guaranteeing efficient utilization, preserving resources, creating quality jobs for Montanans, and ensuring continued economic vitality in Montana.

Efficiency Issues

Increasing energy efficiency to make the best use of Montana's diverse energy resources is the objective of much research and development today. Raw resources include biomass, coal, coal bed methane, coal waste, natural gas, petroleum, solar, water, hydroelectric, and wind. Other energy resources include agricultural (ethanol from grain, etc.), agricultural waste, conservation, ethanol/methanol, garbage, industrial waste/cogeneration, oil shale, petroleum coke, gasoline, refined products, steam, thermal electric, waste heat, waste-produced methane (from sewage, etc.), and wood waste. We need to identify Montana's technological energy efficiency strengths and build on them.

Other efficiency issues in the energy industry relate directly to government policy. Once a concept is past the basic research stage, there can be barriers to locating a pilot plant or production facility in Montana. Our lower tax rate for research and development equipment is an incentive for firms to locate in Montana. But, the increased tax rate for industrial equipment may cause a business to locate production jobs elsewhere. Delays in the permitting process can also be a disincentive for larger facilities such as pilot plants.

Value-added Opportunities

Petroleum refineries and pipelines are the traditional value-adding sectors of the energy industry. But, new players and technologies are coming on the scene — a new generation of wind turbines, pumped storage and natural gas vehicles, etc. We need research to help develop energy technologies that will utilize Montana's abundant energy resources while providing jobs and a better standard of living for all Montanans. Networking within the industry can help us identify ways to apply Montana's traditional strengths in oil and gas production, human resources, and lab resources to add value to coal extraction.

Relevant In-state Research, Application Capabilities, and Needs

The following entities are currently involved in energy related research in the state:

MORE-EPSCoR: Investigators at each Montana university unit have formed Scientific Advisory Committees to develop a five-year strategic plan for Montana's energy research and education. The group of committees is known as the Montana Organization for Research in Energy (MORE). This effort is part of a planning grant from the U.S. Department of Energy (DOE) Experimental Program to Stimulate Competitive Research (EPSCoR). MORE is also gathering information for a grant request to DOE for a Graduate Traineeship Grant under the EPSCoR program.

MEPRA: The Montana Electric Power Research Association (MEPRA) is an industrial affiliate program of Montana State University conducting specific research requested by affiliates at the affiliates' expense. The focus is on transmission, distribution, generation and usage of electric power, especially application of existing technology to alternative uses. MEPRA receives support from its private industry affiliates and the University System. Intellectual property developed belongs to the University and the project sponsor. This model of directed, contract research helps concepts get to the marketplace quickly instead of relying on university researchers to be the driving force in recognizing a potential market. MEPRA's work could uncover value-added opportunities for industry state-wide.

Clean Coal Technology Center: The Clean Coal Technology Center at Eastern Montana College was created to aid economic development in Montana by promoting the use of Montana coal and assisting in developing new coal technologies that will result in cleaner air. Data on current research and technologies will be available by computer.

DNRC: The Montana Department of Natural Resources and Conservation is involved in four energy research activities: safflower as a displacement for petroleum products; ethanol research on biomass using biotech; wind power - cold weather test facility with BPA; photovoltaic - possible use in irrigation. DNRC has also sponsored university research in chemical engineering and agricultural engineering.

Other Montana research projects and institutions include:

— Mountain States Energy - magnetohydrodynamics research under a Department of Energy Project;

— Western SynCoal - coal drying research;

SynCoal™ product photograph.

High Plains Productions/Photo courtesy of Western SynCoal Company

— the Center for Interfacial Microbial Process Engineering;

— Composite Materials Group at MSU - wind energy projects under DOE;

— Montana Tech - petroleum and environmental research;

— University of Montana;

— The National Center For Appropriate Technology;

— Entech/Tetragenics-Hydro Control Systems;

— Mycotech;

— CENEX;

— Conoco;

— Montana Refinery;

— Cement Plants;

— Exxon;

— Billings Generation Incorporated;

— NW Public Power Association;

— Dept. of Energy (Denver);

— Idaho National Engineering Laboratory;

— Edison Electric Institute (EEI);

— Electric Power and Research Institute (EPRI);

— American Gas Association (AGA)/(IGT);

— National Rural Electric Coop Association (NRECA); and

— Northwest Power Planning Council (NWPPC).

External Support Resources

"Networking within the industry is an important need in energy resources."

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Government: Energy resources have received much government attention. In 1990, the Montana legislature ordered the Environmental Quality Council (EQC) to "develop the framework for a proposed state energy policy in cooperation with the Department of Natural Resources and the Consumer Counsel during the 1991-92 biennium." EQC will develop a state energy policy goal statement, establish an ongoing state energy policy development process within state government, develop an energy policy analysis methodology to evaluate and compare energy-related policy options, and promote broad public involvement in its process.

EQC may also evaluate energy conservation and production issues including government uses of energy and standards for choosing and implementing energy efficiency measures; effectiveness of energy efficiency statutes and regulations; options for increasing energy efficiency in buildings; barriers to implementing conservation in the market place; regulations, taxation, and incentives affecting exploration, development, and supply of energy; the state's role regarding transportation fuels and state efforts to encourage energy efficient transportation; and environmental and socio-economic impacts of energy production.

Our focus group chose not to duplicate the work of the EQC, but sees a need for continued communication between the groups and MORE-EPSCoR.

Universities: Much of the energy research and development in Montana is done through the University System. We must maintain and bolster this capability. Funding and infrastructure are a problem. We need to seek out research that will help solve Montana energy problems and develop Montana jobs.

Industry community: Through public/private cooperation the diverse members of the energy industry sector — energy companies and producers, major end-use consumers, government users and regulators, producer and consumer groups, and researchers — have potential to be a strong resource for energy research and development in Montana.

The Montana Electric Power Research Association (MSU) and the Center for Interfacial Microbial Process Engineering (MSU) offer good examples of effective public/private cooperation.

Action Agenda

1. Focus research on areas of strength in the universities, for example: coal drying to reduce the transportation weight of coal and

increase its heating value to give Montana coal the competitive edge; energy conservation applicable to Montana; etc.

2. Strengthen university cooperation with other governmental agencies such as Montana Department of Resources and Conservation, the U.S. Department of Energy, and the Idaho National Engineering Laboratory.

3. Enact a process for the universities and the Montana public to work together to identify up-coming educational needs. Strengthen university degree programs that directly support development of Montana and help solve our problems; refocus programs weak in these areas.

4. Offer a university degree in grain technology (foods, fuels, and alternative uses).

5. Enhance vocational-technical training. There is a growing need for post-secondary workers in high-tech careers, for example, energy conservation technologies. Vo-techs should design their programs to meet the needs of businesses in the geographic areas they serve.

6. Prepare elementary and secondary students for the rigors of technical academic life and communicate information about career opportunities in science and technology.

7. Establish a consistent system of communications between EPSCoR, the U.S. Department of Energy, and the National Science Foundation and increase links between the universities and oil and gas producers.

8. Conduct an exhaustive inventory of energy-related research and development underway in Montana's universities and private sector including institutional strengths. Create an inventory or central library of energy materials, and develop some method to allow easy exchange of information. Energy industry needs should be identified and matched with areas of strength. Likewise, we should look outside Montana for possible projects that would use our strengths, have applications to Montana energy resources, and strengthen our competitive position. Since the goal is to make Montana energy resources more marketable and continue the return to Montana of energy dollars over the long term, money derived from energy resources should be used to fund the effort. Interest from an earmarked portion of the Permanent Coal Trust Fund could be utilized for energy resource research grants. Private entities could match the funds, and royalties would be shared on a prorata basis. Money from royalties would go back into the fund to promote more research. Tax credits for a financial contribution would be an incentive, as would the option to dedicate a portion of a company's taxes to energy research at a Montana university.

9. Develop additional rewards for successful researchers and their universities.

"Through public/private cooperation the diverse members of the energy industry sector...have potential to be a strong resource for energy research and development in Montana."

■ ■ ■

10. Organize technology-transfer seminars to get industry, university researchers, and other interested parties together.

11. Establish a Coalition for Fossil and Grain Fuels Energy Research to seek out a niche within energy research not being addressed by surrounding states. It could include extraction processes, exploration, and production. It could also include research into alternative exploration methods for oil, gas and coal.

12. Remove inordinate barriers to the growth of energy-related research and development in Montana. Enact tax laws that encourage long-term energy research with a goal of expanding into production. Institute competitive rates for Workers' Compensation. Establish a friendly, fast, and fair permitting process that distinguishes between exploration and development. Organize federal/state roundtables to discuss solutions to improve the process.

13. Communicate to the people of Montana the positive value of energy-related research.

14. Maintain and improve the University System. To conduct beneficial research, Montana must have quality researchers and first-rate equipment. We need sustained, significant funding for the University System. We need adequate funding and staffing for the Centers of Excellence. The educational system must have the resources and flexibility to identify and respond to the needs of business and industry in Montana. Likewise private industry needs to support the educational system through matching funds for example.

15. Coordinate research and development activities with EPSCoR and EQC.

Forestry and Wood Products

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Background

The elegant Douglas fir, the stately ponderosa pine, and the heavily timbered slopes of lodgepole pine form the pictures and playgrounds we associate with Montana. Trees are also vital to one of the largest, most important industries in Montana: the forest products industry.

The forest products industry produces a wide array of products from paper to plywood, lumber, posts and poles, particleboard, turpentine, and more. The forest products industry is Montana's largest manufacturing activity, with nearly $1 billion in annual sales. Montana's economy relies heavily on the forestry and wood products industry. Between 1985 and 1989, the wood products industry provided 15% of Montana's basic industry labor income, and 11% of the state's basic industry employment. During the last half of the 1980s the forest products industry accounted for approximately 40 percent of labor income in basic industries in Montana's nine western counties.

After nearly four decades of increasing employment, the 1980s saw substantial declines in forest industry employment — from a high of over 13,000 workers, to about 11,500 workers in the 1988-1990 period. Timber availability is expected to lead to a 15 percent to 40 percent decline in employment in the next ten years.

Needs and Interests

Montana's forestry and wood products industry is in the throes of a major structural change, driven by the demands of a highly competitive and fast moving world economy and by changing societal values.

In response to growing concerns that the nation's forests should not be managed as giant tree farms, a new focus in forestry looks at perpetuating complex ecosystems, accenting what's left behind in the woods rather than what can be removed. The fear is that traditional forestry practices may be creating simplified ecosystems, that we may be losing things we not only don't understand, but that we don't even know exist.

While much of the focus has been on management of national forest lands, decisions made regarding those lands also will irreversibly affect the future of private forestlands in Montana. Those lands are considerable. 11,000 individuals own three million acres of commercial forest land in Montana, twice the acreage owned by Montana's two largest industrial timber companies (Champion and Plum Creek).

Stewardship is the core issue in the management of both public and private forestlands in Montana. There is general acceptance of the concept that forest owners, managers, and users have a responsibility not only to themselves, but also to future generations, for the wise use of forest resources. Forestlands contain, and are managed to support, many resources, including recreation, trees for harvest, forage for sheep and cattle, good fish habitat, food and shelter for wildlife, minerals, water for downstream users, and wildlands for future generations. It is the wise and careful balancing of the use and/or preservation of these various resources that challenges Montana now.

Efficiency Issues

Volume: The volume of national forest timber under contract has fallen to its lowest level since 1962. National forest officials point to a number of related factors causing the low level of sales: appeals and court decisions; lack of resolution of the wilderness issue; old growth timber management requirements; threatened and endangered species and other wildlife constraints; visual quality objectives; cumulative effects on national forest sales from harvests on private lands and past harvest on the roaded portions of the national forests; social concerns expressed in the National Environmental Policy Act process; and greatly increased cost of timber sale preparation coupled with a U.S. Forest Service budget that has not kept pace with increasing costs.

Technology Transfer: At present, equipment manufacturers and distributors are the major sources of information on new technologies for

wood product manufacturers. Private industry groups such as the Montana Logging Association also sponsor industry trade shows and conventions at which new products or processes are presented. We need a more direct technology transfer system among university researchers, government, and industry.

Information: The single greatest efficiency issue cited by focus group members was the lack of adequate and reliable information for long-range decisions regarding:

- resource availability;
- ecological effects of resource utilization;
- economic consequences of resource management or utilization;
- the wisdom of investment in growing, harvesting, manufacturing, or marketing equipment or processes;
- employee hiring and training programs; and
- and appropriate research and development activities and expenditures.

Inadequate information on the location and characteristics of timber and growing sites, past logging activities, road building, human settlements, mining, and agricultural uses makes long-term sustainable decision making very difficult. For example, a major aspect of the timber supply problem is the inability of the national forests to sell the full volume of timber projected under the forest plans. The "shortfall" is due at least in part to the inability of the federal land managers to anticipate the cumulative effects of harvests on intermingled ownerships, and the impacts of these cumulative effects on future sales on national forest lands. This caused the Forest Service to be overly optimistic in planning timber harvest volumes, and it caused the forest products industry in the late 1980s to anticipate more timber than the national forests could deliver.

We also need a reliable source of marketing information. In the past, the Montana Department of State Lands' Division of Forestry provided data on marketing opportunities and activities to Montana producers. Due to budget restrictions, 1992 will be the last year for the Department's basic directory. Unfortunately, no one else has stepped into the breach.

Photo courtesy of Montana Logging Association

European techniques, like log forwarding, may enable harvesting of sensitive sites while meeting the most progressive stewardship requirements.

Value-Added Opportunities

Value-added wood products manufacturers in Montana need basic wood science education and technical assistance. This is essential just to begin to make them competitive in their target markets. To compete in the global marketplace, those who have mastered the basic skills will need production sophistication. A permanent manufacturing productivity center for value-added wood products manufacturers (and other manufacturers) is being explored in northwest Montana.

Reutilization of Wastes

More research on multiple entry strategies, benefits, and constraints is needed to help achieve a reasonable balance between wildlife habitat preservation concerns and more effective utilization of wood fiber to eliminate unnecessary waste.

Forest products businesses also need assistance to overcome liability insurance and bonding problems that keep many small wood waste users (bough and wreath manufacturers, post and pole operators, etc.) from using fiber made available through sawlog entries. Finding ways to use waste wood fiber in the production of alternative building materials and other innovative products should be encouraged.

The use of "hog fuel" and other wood waste materials to produce power for forest product

industries and others could help solve environmental concerns while providing a non-fossil fuel source of energy. Two Montana companies now have or are building hog fuel-fired generating plants. To encourage similar activities, we need more research and development of affordable equipment to minimize air pollution problems frequently associated with the burning of wood waste.

Alternative Uses for Raw Materials and Products

We need research in preserving the useful life of wood products and making more productive use of available trees. For instance, a great deal of wood is sold in warm, moist climates for house decking, where it deteriorates rapidly and probably constitutes an unwise use of a wood product. Development of attractive, cost-competitive alternatives for homeowners would help conserve needed wood for more appropriate uses. Penta, CCA, and other wood preservatives have been shown to have negative health or environmental effects. Innovative treatment techniques to make wood last longer would reduce overall wood demand.

"During the last half of the 1980s the forest products industry accounted for approximately 40 percent of labor income in basic industries in Montana's western counties."

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Research into ways to make lighter, but stronger, structural wood products has potential to reduce raw material utilization, increase product quality, increase building design options, and reduce product transportation costs. The Montana Science and Technology Alliance has already supported some research in the increased utilization of small diameter lodgepole pine for structural components, but there is still a great deal to be learned in this area. More effective use of small diameter larch should also be studied.

Relevant In-state Research, Application Capabilities, and Needs

The University of Montana's School of Forestry received a grant in 1991 to study possible value-added wood products development and marketing via a small business assistance research laboratory. The University already has produced a secondary wood products manufacturers directory. Energetic pursuit of this opportunity for enhancing "value-added" research and technical assistance capabilities should continue at the University, with strong input and support from state government and from the wood products industry itself.

There is currently no ongoing research on timber harvesting systems in the northern Rocky Mountain region. We need research in harvesting techniques (from stump to mill) in close collaboration with silvicultural researchers, to insure harvest techniques that are compatible with public values.

Action Agenda

1. Create a comprehensive multiple resource inventory. Successful multiple resource management requires careful analysis of the interrelated effects of proposed activities on various interconnected ownerships. This kind of management requires the support of a comprehensive inventory system.
2. Educate the private timber owners and the general public in stewardship issues. An informed public can better understand and appreciate management questions facing forest planners, and can better advise public policy makers about the decisions which must be made. Stewardship education could begin at the grade school level — and should be a lifelong learning experience.
3. Support the University of Montana School of Forestry's value-added wood products development, marketing, and small business assistance research laboratory.
4. Support the gathering and dissemination of wood products marketing information at the University of Montana, and coordinate closely with existing local and regional marketing projects.
5. Support the creation of wood products manufacturing networks.
6. Remove government barriers to the forest product industry's competitive position. Specifically, the issues of high workers'

compensation costs and personal property taxes on manufacturing equipment were cited as competitive disadvantages.

7. Create industry- and skill-specific community college and vo-tech based training programs, designed and implemented with extensive private business participation, to educate workers and management.
8. Create manufacturing productivity programs to bring Montana manufacturers up to world- class standards.
9. Pursue basic and applied research in harvest techniques in cooperation with the Intermountain Research Station.
10. Support research in wood waste utilization and more effective utilization of existing wood supplies.
11. Provide education in negotiation and dispute resolution technologies.

"We need research in preserving the useful life of wood products and making more productive use of available trees."

■ ■ ■

Mineral Extraction and Processing

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Big Timber

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Representative Ed Grady
Canyon Creek

Representative Bob Raney
Livingston

Background

From gold in Silverbow County, to platinum in Stillwater and Sweet Grass Counties, to copper and silver in Lincoln County, today's mineral production is as diverse as the people of our state...bentonite, phosphate rock, limestone, silica, vermiculite, barite, gypsum, iron ore, molybdenum, chlorite, platinum, palladium, talc, sulphur, chromium, gold, silver, lead, zinc, clay, sand, and gravel...the list is nearly endless.

Mineral extraction and processing is Montana's fastest growing basic industry, growing by more than 100% over the past ten years. The industry directly employs approximately 5,380 people with an annual payroll of $161,251,000, and indirectly employs 8,520 more people statewide with a $110,619,000 annual payroll. Last year, mineral extraction and processing generated more than $61 million for the State of Montana in taxes. But, last year also saw a 50% decrease in mineral exploration on National Forest lands and a 75% reduction in analytical/assay business.

Needs and Interests

The greatest need and interest of the minerals extraction and processing industry is to find a way to balance industry needs with environmental concerns while shepherding resources for the future. Most mining extraction takes place on public land — land that must support many other resources, including forests, recreation, wildlife habitat, grazing, water, etc. Mining laws and permitting processes are intended to help. Montana mining operates under the nation's Mining Law system, which consists of the General Mining Law and state and federal laws passed subsequently to protect the environment. The public has legitimate concerns about this system of laws; however, many criticisms are based not on modern mining practices but on past history, and are fed by emotion rather than scientific fact.

Efficiency Issues

Wait time: Mineral extraction is a high-risk venture requiring a large investment of capital up front and a relatively long wait period until minerals are extracted and a profit is realized. Time delay is the biggest efficiency issue for the mineral industry. Wait time could be cut drastically by streamlining government processes.

Mineral resources information: The industry needs easily accessible, well organized maps, drawings, records of old mines, county-by-county mineral inventories, and other basic geological data. The Montana Bureau of Mines and Geology is organized for this purpose. But, because of federal Superfund funding and limited state funding, the Bureau's current emphasis is more on hydrogeology than geology and mineral resources.

Shipping: High costs or delays in hauling mineral products to ports and shipping hubs affect efficiency and profit. To avoid delays, some companies purchase or lease rail cars. Others ship by truck, but deadhead loads increase costs. Freight rate structures can be a disincentive for adding value to Montana minerals. Freight rate structures and insurance for finished products usually are higher than for raw materials.

Taxes: To encourage the mineral extraction and processing industry to add value to raw resources, state taxes should be restructured to be consistent with encouraging added value, such as deductions for benchmark levels of value added or jobs created.

Compliance: Montana's compliance costs are typically higher than neighboring states. Montana's requirement for a flatter slope can lead to more earth moving costs, more disruption of terrain, and greater reclamation costs in the end. We need stability in bonding and in the cost of compliance as well as consistent regulations from agency to agency, and from the state to federal level.

Workers compensation insurance: Most large mineral extraction and processing industries are insured for workers' compensation through private carriers because the rates are lower. Montana Workers' Compensation should re-evaluate its mineral extraction rates in consideration of the industry's excellent safety record.

Energy: The price of power is the largest single cost for most mineral extraction and processing industries. Until recently, the supply of hydroelectric power far outstripped demand. Now we are in a phase of balancing resources and demand. New power resources are expensive and require extensive permitting. Conservation is becoming the resource of choice. Higher prices or limited supplies of electric power restrict new mineral industries, especially smelters, and may force out existing industries that rely on electric power.

Information Coordination/Networking: Minerals extraction and processing industries need a routine communications process with the Department of Commerce, the Center for Advanced Mineral Processing at Montana Tech, the Entrepreneurship Center, the Montana Chamber of Commerce Waste Resources Brokerage Network and others that know government and industry product needs and the capabilities of Montana's mineral industries. Fast, electronic communication of opportunities is mandatory. We need regular coordination with manufacturing to identify prospective markets and opportunities to cooperate in the manufacturing process.

Value-added Opportunities

Montana's mineral extraction and processing industry produces some processed materials such as aluminum sheet ingot and pre-stressed concrete products. But, there is much more potential for adding value to mineral products. To compete effectively in the global arena, we need to identify and take advantage of unique resources and unique mineral properties and characteristics. The potential for adding value to some minerals is obvious; others will require more research. For instance, Montana produces 36% of total U.S. talc. Montana talc has an extremely low asbestos content. Because of its unique absorption properties, a large amount is used in the paper industry for "pitch control." These same properties make Montana talc unsuitable for most cosmetic uses, despite its high average brightness factor. Our talc seems to have spin-off possibilities in oil spill cleanup, plastics, insulation, catalytic converters, ceramics, dry lubricant, and paint manufacture. With renewed concern about the highest and best uses of finite resources, we should investigate potential uses for low-grade talc.

In some cases, mineral value could be increased by adding a level of processing or packaging (because of market conditions, mineral quality, and other considerations, not all may be candidates for adding value through processing). Mines could add a level of value to raw or crude products by milling and bagging. Foundries could add the next quality level of castings to compete for a greater range of higher-spec opportunities. There may be an opportunity to substitute Montana sand for imported olivane sand used in the foundry process. We need to apply the latest technology to expand and upgrade the ASARCO lead smelter to produce at least lead and zinc pig. Montana also could benefit from a die-casting facility and a state-of-the-art smelter capable of processing a variety of ores.

Reutilization of Wastes

The most common mining wastes and by-products include tailings, slag, dredge tailings, sand, processed rock, cyanide, heavy metals, and acid. A major challenge in reutilization is the

Aerial view of the Columbia Falls Aluminum Company.

Photo courtesy of Columbia Falls Aluminum Company

sheer volume of waste and by-products. Burning waste in cement kilns is part of the solution. It would provide fuel for the kilns, destroy hazardous waste, and keep money and jobs in Montana. Recycling is another part of the solution. Old tires could be reprocessed into asphalt and pavement top coating. Fifty-five gallon shipping/storage drums could be returned for cleanup and reuse. Mineral extraction industries pay to have waste oil and grease hauled out of state for recycling or reprocessing. We should explore recycling waste oil and grease in Montana. A small volume aluminum recyclery with the capacity to remelt scrap into "sow" might be a good prospect for Montana.

"Conservation is becoming the resource of choice."

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Biotechnology offers waste remediation possibilities in enhanced leaching, water cleanup, and surface remediation via research into resistant plant species, removal of toxics from the soil through metal ion uptake, and creation of wetlands. Biotechnology can update metals, change the species to a less toxic form, and make potential pollutants less mobile so they'll stay in place. Bioleaching technology uses microorganisms to ease environmental impacts of ore extraction and processing. It is a relatively new technology, with known applications for gold, copper, uranium, and coal. We need additional research to help us understand how to harness its full potential and give us a better handle on environmental cleanup.

In the mineral processing industry, the waste product of fabricated metal is scrap metal that can be recycled at a foundry. The waste product of foundries is sand. Foundries wouldn't bleed off sand if they had access to a thermal recycler, cost prohibitive for Montana's lone foundry.

Alternative Uses for Raw Materials and Products

Cement plants could produce highway dividers and railroad ties as well as bulk and bagged products. Montana has a ready supply of natural gas (for ammonium nitrate), sulphur, phosphate rock, and limestone: key ingredients for fertilizer. We also have a substantial in-state end user in agriculture. Ammonium nitrate from natural gas is also an oxidizer and essential component in blasting agents commonly used in the mining industry. Limestone could be manufactured into soil conditioners or environmental remediants. Montana has the petroleum products and talc to manufacture plastic prills, the basis for plastic extrusion products. With the addition of a die-casting facility in Montana, we could produce and assemble many products entirely in-state.

Relevant In-state Research, Application Capabilities, and Needs

Basic research to identify the unique properties of minerals will help the minerals extraction and processing industry develop an inventory of mineral resources that could be cross-referenced by unique or characteristic chemical/physical properties. Knowing heat and cold tolerance, magnetism, bonding capabilities, etc., especially in regard to minerals, by-products, and waste now thought of as "low-quality," "nuisance," or "hazardous," could open up whole new markets for minerals. We also need economic research to analyze Montana's mineral economy and identify markets, develop value-added possibilities, and determine what products could be profitably produced or provided in-state. Funds are needed to conduct research and implement activities to add value to mineral extraction and processing. Direct state support of basic research programs at Montana's universities is the key to attracting and maintaining federal research dollars and joint research projects with private industry.

External Support Resources

Although Montana's education system is highly touted, most minerals industries job applicants lack sufficient skills in communication, spelling, grammar, and math, not to mention technical skills, to succeed at work. Most have a strong work ethic but do not understand how the American economy operates or how industry works. Montana should institute a trades/vocational curriculum at the secondary school level including basic skills such as welding, operating a drill

press, etc., and academic courses explaining how businesses operate. Teachers also need to learn more about how business and industry work. Teacher internships during the summer are one way to expand teacher understanding through on-the-job training in industry.

Action Agenda

1. Support basic research to identify the unique properties of minerals to develop an inventory of mineral resources that could be cross-referenced by unique or characteristic chemical/physical properties.
2. Conduct economic research to analyze Montana's mineral economy and identify markets, develop value-added possibilities, and determine products that could be profitably produced or provided in-state.
3. Institute "one stop permitting" at the state, designating a lead agency for the minerals extraction and processing industries to coordinate all permitting for the industry. Streamline government processes by defining requirements for approval and implementing a standardized approval schedule with benchmarks guaranteeing government response, approval, or rejection at specific points in the process within a certain amount of time.
4. Support the use of waste materials as a source of energy.
5. Help cement plants obtain the technology and equipment to produce castings. Help extractors and processors obtain the technology and equipment to upgrade raw or crude products to milled or finished products. Help foundries obtain the technology and equipment to add the next quality level of castings. Help obtain and apply the latest technology to expand and upgrade smelters to add value to ore processing.
6. Encourage the development of a fertilizer manufacturing plant in Montana to utilize the supply of sulphur, limestone, natural gas, and phosphorite; and a plastic prill manufacturing facility, combining petroleum products and talc, for plastic extrusion products.
7. Investigate using the Port of Montana in Butte as a statewide dispatcher.
8. Expand opportunities for teachers to intern at mines during the summer and for classes of all grade levels to tour mines throughout the school year. Encourage workers to participate as speakers at career days, Expanding Your Horizons workshops, and other career opportunity activities.
9. Establish a system of routine communications among the Montana Department of Commerce, the Center for Advanced Mineral Processing, the Entrepreneurship Center, and the Montana Chamber of Commerce Waste Resources Brokerage Network and others that know government and industry needs and the capabilities of Montana's mineral industries.
10. Restructure the state tax system to encourage the mineral extraction and processing industry to add value to raw resources through deductions for benchmark levels of value added or jobs created, etc.
11. Investigate the effectiveness of compliance requirements of surrounding states and adopt those that do a better job of protecting both industry and the environment.
12. Encourage public/private partnerships, federal contracts, and private industry contracts to enhance the geology and minerals focus of the Montana Bureau of Mines and Geology.

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Background

Assyrian iron, Arabic numerals, Greek philosophy, the Roman phalanx, the British steam engine, American electronics and information technology...a nation's wealth is created by intellectual innovation, not mere exploitation of resources. Many of the next great innovations are likely to be in the biotechnology and surface sciences, areas in which Montana has a good start.

Innovation requires research. While basic research is directed toward developing new scientific understanding of a fundamental nature, it is often motivated by and is never far from use in solving practical problems of economic importance. Essentially all new technological industry springs from basic research.

Research is a huge industry attracting hundreds of billions of dollars yearly worldwide, about $300 billion in the U.S. alone. Our federal government spends nearly $100 billion per year on research, about 15% of which is in basic research. Basic research is a significant industry in Montana, playing an important and vital role in the state's economic development. Basic research in the MUS alone brings about 35 million new dollars a year into the state in research grants and contracts. Every state dollar invested in research infrastructure in the MUS attracts three to six new dollars. Basic research also creates a pool of people, techniques, expertise, and instrumentation that support people working on particular problems of practical importance.

Needs and Interests

Montana research has a special interest in implementation of this action agenda to provide a blueprint for state-supported research to benefit Montana. There is considerable help available to Montana from the federal government if we can demonstrate a state commitment to research policies, plans, and infrastructure.

Education also is a major interest of basic research. In early times research was usually done by extraordinary individuals with time, money, curiosity, and a major practical problem to solve. Research began to be formalized only in the latter half of the nineteenth century when groups of highly educated people worked in universities under the direction of a leader. Research is the primary route by which scientists and engineers are educated, and a primary route by which new scientific knowledge is brought into Montana. Basic research is also the primary route by which MUS faculty members keep their classroom teaching current and enthusiastic. Students who are part of a first-class research group often choose science careers, forming the core of Montana's technological base.

The major needs of basic research result from weaknesses in the university system. Effective research requires the support of the MUS to at least the level of its peer institutions. If the MUS is to develop increased strength in research, faculty must be valued and rewarded. Research must be visible in the office of the Commissioner of Higher Education. We need that office to take leadership in system-wide research projects to benefit the entire state.

Another issue for university researchers is that the secrecy associated with protection of a commercial property can conflict with publication vital to a research career. It is necessary to be very sure of the commercial value of a discovery before undertaking the secrecy required for commercialization. Many opportunities are overlooked because the primary focus of the researcher is on the experimental problem, not on its commercial potential.

Efficiency Issues

Research efficiency issues in the MUS are related primarily to people, although the lack of modern instrumentation, laboratories and support services also are important.

Faculty Salaries/Recruitment: The demand is fierce for people with the intellectual ability, imagination, motivation, and energy to develop competitive research programs. The MUS usually is not competitive. Recruiting budgets must be increased.

Start-up Funds: Start-up funds are necessary to develop competitive research programs. A new faculty member will need to equip a laboratory and get it running before he or she is likely to obtain outside funding. Candidates often regard salary, start-up funds, laboratories facilities, and technical support as a package, and choose the school offering the best package.

Teaching Loads: Maintaining a competitive research program demands time as well as intellectual, emotional, and physical energy. Teaching loads in the MUS need to be adjusted to give active researchers time to maintain their programs. A teaching load of more than one course per semester is too high.

Graduate Students: Research programs require graduate students who contribute their minds and hands for a few years in return for financial support to attend the university and apprentice in their chosen profession. The success of a research program depends largely on the number and quality of its students. The competition for quality graduate students is sometimes as fierce as for faculty. Most good science and engineering graduate students are supported by either research or teaching assistantships. The MUS is far behind even its peer institutions in both the number of teaching assistantships available and the level of financial support.

Faculty Development: Faculty development in the MUS largely involves overcoming isolation. To remain competitive, faculty need opportunities to attend scientific meetings, take sabbaticals, have access to a wide range of library facilities, and invite experts to Montana for consultation and seminars. Part of the reason Montana scientists have difficulty winning grants, especially at the mission-oriented federal agencies, is that evaluators do not know of scientific strengths in Montana.

Incentives for Research: To encourage faculty to pursue grants, the MUS should develop additional financial incentives such as increased merit salary increments and rights and royalties related to intellectual property, e.g., patentable discoveries that can be commercialized.

High Plains Productions/Photo courtesy of Deaconess Research Institute

Deaconess Research Institute's new LUNAR DEXA unit performing a bone mineral content scan.

Equipment/Instrumentation: Montana researchers cannot be competitive without a strong instrumentation base. For example, the UM Department of Chemistry is using an FT-NMR instrument jury-rigged from a used instrument in 1982. Proposals from UM involving NMR techniques won't compete well with proposals from institutions with state-of-the art NMR instrumentation. While there are areas of adequate to quite good instrumentation within MUS, the general picture is mediocre.

Maintenance and Construction: There are continuing expenses to keep equipment running. Intricate modern instrumentation is complex and contrary. It needs a curator for day-to-day and exceptional maintenance, to modify set-up, and advise researchers on most advantageous use of its power. There also need to be centralized, competently staffed electronics and machine shops, etc., to solve problems and construct state-of-the-art instrumentation.

Buildings: Research requires laboratory and office space. Space is probably approaching adequate in the MUS for the current level of research, although UM Biological Sciences and Biotechnology and most areas at Montana Tech need more space. Available space often is not suitable for research. Any significant increase in research faculty or activity will require more space.

Low Level of Funding: Very little further development of basic research can be expected until funding levels in the MUS are brought up to the

peer average of universities in surrounding states with populations and per capita incomes very similar to Montana's.

Lack of a State Research Agenda: The problem with support of science in Montana is not only money; there must also be a commitment by the State of Montana to create and implement a statewide plan.

Administration: Accounting and purchasing procedures designed for activities other than research are awkward for faculty administering research grants or contracts.

Relationships Among Research Capabilities

Basic research in Montana has strengths in areas as diverse as molecular biology, astrophysics, biology, paleontology, chemistry, and statistics and in interdisciplinary areas such as nonlinear dynamics, environmental science, plant pathology and plant breeding. There is a cadre of very fine scientists working in the MUS and a substantial, although not adequate, research infrastructure. There are particularly strong people in biological sciences, chemistry, forestry, geology and mathematics at UM; in engineering, agricultural sciences, astrophysics, surface sciences, chemistry and biological sciences at MSU; and in various mineral-related sciences at Montana Tech.

Basic science creates a collection of people, skills, knowledge, and equipment that attracts funded research activity into the state in its own right and employs applied researchers. The scientific expertise associated with strong basic research in the MUS can help alleviate the isolation of industrial and governmental scientists and engineers who attract technical people and associated industries as well as other people doing intellectual work. Examples of such interactions include the close relationships between UM and the Rocky Mountain Laboratory and Ribi ImmunoChem, Inc. in Hamilton, as well as various U.S. Forest Service Laboratories, Chromato-Chem, Inc., UltraFem, Inc. and Nurture Biotech, Inc. in Missoula, between MSU and Skyland Scientific, Biosciences Laboratories, and between Montana Tech and several mining companies, Montana Technologies Company and the Center for Appropriate Technology.

"Basic researach is an industry in its own right, bringing new dollars into Montana in the form of grants and contracts."

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Research cooperation among the various units of MUS should be fostered. This could be done through telecommunication among the units for transmission of graduate courses and cross-registration among the units so that a graduate student at one institution can take advantage of an educational opportunity at another. A daily shuttle service between UM and MSU with a stop at Montana Tech would be very valuable.

Potential Contributions to Montana Industries

Basic research is an industry in its own right, bringing new dollars into Montana in the form of grants and contracts. It is low-profile, clean, not exploitive of people or limited natural resources, and supports relatively high-income jobs in Montana. Each top-level scientist supports ten other scientists and an equal number of non-technical staff. Research has an immediate spin-off in specialty instrument manufacture. It is not uncommon for people involved in designing and constructing custom equipment for researchers to eventually go into business manufacturing and selling this equipment.

A considerable amount of basic research in Montana is devoted to improving the productivity of the agriculture, forestry, minerals and other industries. This basic research relates to applied research in areas important to the state's economy. Specific areas in which basic research can contribute to practical problems are detailed elsewhere in this Action Agenda.

External Resources

Federal Funding: Only about $35 million (0.035%) of the federal government's $100 billion research budget goes to the two major research

universities in Montana, the University of Montana (UM) and Montana State University (MSU). Montana and nine other states together receive only five percent of the federal government's research budget. Montana, Wyoming, Idaho, South Dakota and North Dakota receive only 30% of what the other deprived states get. Even on a per capita basis Montana receives only about 40% of the national average. Federal research grants are allocated competitively through research proposals. Montana science often cannot compete well with states with highly developed scientific infrastructure and better known scientists and universities.

EPSCoR: There is some help becoming available through the Federal Experimental Program to Stimulate Competitive Research (EPSCoR) programs, initiated in 1980 by the National Science Foundation (NSF) to help states not competing well for federal research support. There are now eight federal agencies with EPSCoR-like programs: NSF, NIH, Department of Energy (DOE), Department of Defense (DOD), Department of Agriculture (USDA), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), and Department of Transportation (DOT). Over the next three years, $150 million to $200 million will be available in these EPSCoR programs.

Montana was one of the first states to participate. In Montana, NSF EPSCoR goes by the acronym MONTS (Montanans On a New Track for Science). MONTS funds individual principal investigator (PI) proposals and concentrates on improving the national competitiveness of the individual scientist. The MONTS program has helped improve the research atmosphere in Montana with a remarkably small amount of money, about $600,000 a year combined state and federal funds. From 1975-79 there were only 100 proposals submitted to NSF from Montana. That figure and the per annum dollar volume have quadrupled since then, with 100 fewer faculty in MUS. Montana's success rate at NSF increased from 22% in 1979 to 36% (better than the national average).

Montana's 1991 proposal to continue in the NSF EPSCoR program was not funded. The major reason for Montana's failure was a perceived lack of commitment to science by the State of Montana. The very poor level of funding of MUS was cited, as was the lack of any central state-coordination of science. It was noted that there never has been any new state money available for the 1:1 match required. The proposed match in the 1991 proposal was a loan from MSTA, not grant money as preferred by most university researchers.

Action Agenda

1. Bring MUS up to the per student level of support of its peer institutions.
2. Secure acknowledgement from state government that basic research can and should be done in Montana.
3. Allocate state matching funds to meet EPSCoR requirements.
4. Aggressively pursue federal "earmarked" funds to help implement the Action Agenda.
5. Organize workshops to educate investigators to recognize the commercial value of a discovery.

Biotechnology

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Background

Biotechnology is the technology of living matter, harnessing nature to meet the needs of man. It includes any technique that uses living organisms (or parts of living organisms) to make or modify products. World sales of biotechnology products are projected to reach $180 billion by 1994. Many analysts predict that biotechnology will rival, or even surpass, the electronics industry in economic impact. In 1991, considered a dreadful economic year, biotechnology firms raised $35 billion in capital for research and development.

Seventy-five biotechnology research centers are funded in 33 states, with average annual state funding of $3.7 million per center. The average number of full-time employees in state biotechnology centers is 30, including eight associated faculty members. Federal spending for biotechnology in the fiscal year beginning October 1992 will increase seven percent to $4.03 billion.

Compared with most other states, Montana's biotechnology in both the university system and the private sector is embryonic. This can be attributed to lack of public awareness about biotechnology and its potential; lack of substantial, sustained support by administrative, legislative and the financial sectors; a conservative approach toward risk-taking by public and private organizations; detrimental tax legislation; and lack of large private and public institutions and industries with the intent and the financial strength to support biotechnology-based projects.

Needs and Interests

Successful biotechnology requires a vigorous and stably funded basic research establishment. A major factor affecting our ability to assemble a first-rate basic research establishment is increased demand on researchers' time. Faculty have been required to take on more administrative and service tasks, to the detriment of productive, salable basic research. University faculty must be allowed to balance teaching, service, and research.

We need an effective mechanism to identify, protect, and promote new ideas at early stages of development and to make outside investors aware of breakthroughs. We need appropriate support at each stage of biotechnology development: 1) Basic Research; 2) Technology Transfer; 3) Idea Development; and 4) Commercialization and Marketing, and assistance to move from one stage to the next.

Skilled protection of intellectual property is a top priority need of biotechnology in Montana. This function is not being well provided now. Researchers are sometimes unaware of the commercial potential of an initial discovery or unsure of how to proceed or whom to contact for commercialization advice or support. We need a highly trained facilitator at the state level to regularly contact researchers and provide advice on commercial potential.

Biotechnology needs stable, long-term, nonpoliticized support for real economic growth, long-term job creation, and economic prosperity for Montanans.

Coordination of Public/Private Research

In Montana we have significant, but uncentralized, resources for biotechnology. For example, the Rocky Mountain Laboratories, a federally-funded laboratory in Hamilton, has more than 50 doctoral level scientists and an arsenal of state-of-the-art equipment unmatched elsewhere in the state. The Center for Interfacial Microbial Process Engineering in Bozeman, which focuses on environmental biotechnology, is one of 18 National Science Foundation-sponsored Engineering Research Centers. The McLaughlin Research Institute in Great Falls, the Deaconess Research Institute in Billings, and others, add resources that are not being effectively utilized.

Montana possesses a small, but fine, core of biotechnology based researchers both within and outside the university system. Within the university system, most are located at the University of Montana and Montana State University. Every unit has at least a small cadre of people with excellent ideas and potential. Additionally, the

physical facilities needed for first-class research are, for the most part, in place. The number of skilled researchers necessary to interact and to form an effective critical mass of biotechnology, however, is not.

There are exceptional collections of instrumentation and relevant associated expertise. Prime examples include MSU's Nuclear Magnetic Resonance, Mass Spectroscopy and Molecular Modeling facilities, and UM's recently opened molecular biology and electron microscopy centers. Western Montana College has a fine, broadly-based electrophoresis laboratory, but desperately needs spectroscopic capabilities. This unevenness in instrumentation is particularly acute at the smaller institutions. Many of the well instrumented facilities are critically short of personnel to operate the instruments, teach new users, upgrade existing equipment, and manage maintenance.

The Center of Excellence in Biotechnology is ideally situated to carry out many of the recommendations of the Focus Group on Biotechnology. Since its creation in 1987, the Center has been a focal point for biotechnology development. It should continue in that role with an expanded mission and significantly increased budget. The Center should perform liaison and outreach between the university system and parties interested in commercialization; promote collaboration among investigators; provide funds for conceptual research with commercial potential; plan to develop the critical mass of expertise necessary to support and to stimulate biotechnology; develop methods to educate students (K-12) and the public on the practice and the potential ofbiotechnology; represent, display, and promote Montana's biotechnological capabilities at national associations; identify and promote awareness of Montana opportunities or problems suited to biotechnology-related solutions.

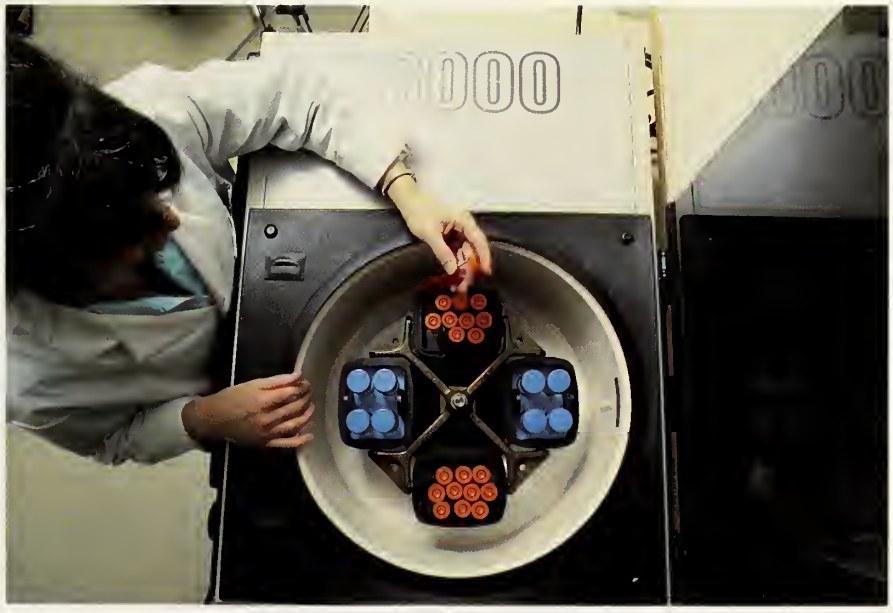
Potential Contributions to Montana Industries

It is critical to the economic development of Montana that we vigorously pursue a productive niche in biotechnology emphasizing our traditional strengths and interests as well as developing new areas. In the years ahead, biotechnology could provide lucrative and interesting jobs for a significant number of our citizens.

External Support Resources

Successful biotechnology requires a vigorous and stable basic research establishment aware of economic potential. For the most part, that basic research is provided by the university system. Without a vital university system, any attempts to develop biotechnology will fail. The university system is an extremely valuable state asset for generating new ideas, defining new research areas, discovering innovative answers to difficult problems, and for developing new businesses in Montana.

Research & Development technician at Ribi ImmunoChem Research, Inc. using a large centrifuge



Bryant Photographics/Photo courtesy of Ribi ImmunoChem Research, Inc.

Action Agenda

1. Educate the public about the present and future value of basic research. Research must be viewed not as a frill, but as a wise investment in the economic well-being of our state.
2. Stabilize funding to enhance basic research in the University System. This should not be done via tax revenues, but rather from the coal tax fund or some other stable source of long-term funding. The University System as a whole must be funded at a level which will allow it to compete successfully for outside support such as EPSCoR.
3. Provide core facilities, including a cadre of skilled operators in the areas of Nuclear Magnetic Resonance and Mass Spectroscopy, Molecular Modeling, Nucleotide Sequencing and Synthesis, Peptide Sequencing and Synthesis, Macromolecular X-ray Crystallography and Electron Microscopy, to basic researchers throughout the state. Operators would help explore ideas, train new users, and keep equipment functioning at peak efficiency.
4. Establish a system of rotating research chairs, providing 50% released time for promising research faculty, chosen on a competitive basis.
5. Use advanced communications systems, up-to-date-inventories, and regular meetings to effectively link and use research resources and build a critical mass in specialized areas.
6. Involve K-12 teachers in basic research laboratories during the summer months, and increase involvement of university researchers in K-12 science lectures.
7. Make available a small fund that could be applied quickly to protect university research discoveries.
8. Provide state and local tax incentives for investment in research and development.
9. Create an up-to-date, central pool of biotechnology-related information about people, projects, and resources, in and out of state.
10. Provide adequate financial and administrative support for the University System.
11. Establish a system for early protection of intellectual property through knowledgeable and effective technology transfer.
12. Provide appropriate financial support at each stage of biotechnology development and assist in moving effectively from one stage of development to the next.
13. Improve public awareness about biotechnology.
14. Strengthen K-12 science and mathematics education.
15. Provide stable, long-term, non-politicized support for biotechnology through continuted and expanded funding for the Center of Excellence in Biotechnology.

Glossary of Acronyms

AERO — *Alternative Energy Resources Organization*

AGA — *American Gas Association*

APHIS — *Animal and Plant Health Inspection Service*

ARS — *Agricultural Research Station*

BPA — *Bonneville Power Administration*

CAB — *Certified Angus Beef*

DNRC — *Montana Department of Natural Resources and Conservation*

DOD — *U.S. Department of Defense*

DOE — *U.S. Department of Energy*

DOT — *U.S. Department of Transportation*

EEI — *Edison Electric Institute*

EPA — *U.S. Environmental Protection Agency*

EPRI — *Electric Power and Research Institute*

EPSCoR — *Experimental Program to Stimulate Competitive Research*

EQC — *Environmental Quality Council*

JTPA — *Job Training and Partnership Act*

MAES — *Montana Agriculture Experiment Station*

MEPRA — *Montana Electric Power Research Association*

MHD — *Magnetohydrodynamics*

MONTS — *Montanans on a New Track for Science*

MORE — *Montana Organization for Research in Energy*

MSTA — *Montana Science and Technology Alliance*

MSTAC — *Montana Science and Technology Advisory Council*

MSU — *Montana State University*

MUS — *Montana University System*

NASA — *U.S. National Aeronautics and Space Administration*

NIH — *U.S. National Institutes of Health*

NMR — *Nuclear Magnetic Resonance*

NRECA — *National Rural Electric Coop Association*

NSF — *National Science Foundation*

NWPPC — *Northwest Power Planning Council*

PI — *Principal Investigator*

R&D — *Research and Development*

SCS — *U.S. Soil Conservation Service*

UM — *University of Montana*

USDA — *United States Department of Agriculture*

VMB — *Veterinary Molecular Biology*

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State of Montana
Office of the Governor
Executive Order No. 4-92

WHEREAS, Executive Order 13-90 created the Montana Science and Technology Advisory Council; and

WHEREAS, it is the policy and goal of the State of Montana under Title 90, Chapter 3, MCA, "to encourage scientific and technological development within the state in order to keep pace with a changing economic structure and to create new jobs and expand business opportunities"; and

WHEREAS, scientific research is a major component of a state's economic development strategy; and

WHEREAS, the development of new technology and its application has been viewed as critical to the long-range economic and social future of the state and na tion; and

WHEREAS, the Montana Board of Science and Technology Development ("Board") has been successful in creating a partnership among the private sector, the university community and state government, to assist in the advancement of scientific and technological development in the state; and

WHEREAS, the creation and development of a state science and technology plan will identify basic research capabilities in the state; assist in the development of a research agenda; strengthen Montana's efforts in applied science and technology; and further serve to develop the partnership among the private sector, university community and government; and

WHEREAS, in July 1991 the Science and Technology Advisory Council issued the Montana Science and Technology Plan;

NOW THEREFORE, I, STAN STEPHENS, Governor of the State of Montana, by virtue of the authority vested in me by the Constitution and laws of the State of Montana, and specifically section 2-15-122, MCA, do hereby extend the existence of the Montana Science and Technology Advisory Council.

I. Purpose

The Council shall:

1. Continue as the policy development arm of the state to carry out activities defined in the Montana Science and Technology Policy and Plan.
2. Appoint focus groups, after consultation with the Governor.
3. Hire and manage the fundraiser for the science and technology capital fund drive.
4. Give continuing advice and counsel to the Governor, the legislature, and other state agencies involved in science and technology.
5. Produce or update the Science and Technology Plan biennially.
6. Provide advice and counsel to the Montana Board of Science and Technology Development on specific applications for research and development project loans as they relate to the Montana Science and Technology Plan.
7. Oversee the implementation of all elements of the Montana Science and Technology Policy and Plan.

II. Composition

The Council shall consist of eleven members. The names and addresses of the members who shall serve at the pleasure of the Governor are:

John Brower — 2 years
MSTA Board Member
384 Little Basic Creek Road
Butte, MT 59701

Walter Hill — 1 year
Professor of Biochemistry
Director of Center of Excellence in Biotech.
University of Montana
Missoula, MT 59812

Robert E. Ivy — 2 years
President, CEO and Chairman
Ribi ImmunoChem Research, Inc.
P.O. Box 1409
Hamilton, MT 59840

Richard K. Quisenberry — 2 years
Vice President and Research Director
The DuPont Company Experimental Station
328/411 Wilmington, DE 19889-0328

Carl E. Russell 1 year
Executive Director
Montana Science and Technology Alliance
46 North Last Chance Gulch, Suite 2B
Helena, MT 59620

Clarence Speer 1 year
Professor and Head of Veterinary Microbiology
Montana State University
Bozeman, MT 59715

David Toppen 1 year
Deputy Commissioner for Academic Affairs
The Montana University System
33 South Last Chance Gulch
Helena, MT 59620

Hartwig Moeller 2 years
3227 9th Avenue, South
Great Falls, MT 59405

Ken S. Walker 1 year
U S WEST Communications
999 Main Street, 11th Floor
Boise, ID 83703

Gerry Wheeler 2 years
Assistant Vice President of Academic Affairs
Montana State University
211 Montana Hall
Bozeman, MT 59717

One Vacancy

Robert E. Ivy shall serve as Chairperson.

A majority of the membership of the Council constitutes a quorum to do business.

III. Compensation

Council members eligible for compensation under 2-15-122(5) shall be compensated by the Department of Commerce at the rate of $25.00 for each day actually and necessarily engaged in the performance of Council duties. All members shall be reimbursed for travel expenses pursuant to section 2-15-122(5).

IV. Duration

As required by section 2-15-122, MCA, the Science and Technology Advisory Council shall exist for a period of two years from the effective date of this order, unless extended by Executive Order.

EFFECTIVE DATE : This order is effective immediately.

GIVEN under my hand and the GREAT SEAL of the State of Montana, this twenty-fourth day of February in the year of our Lord, one thousand, nine hundred and ninety-two.

STAN STEPHENS, Governor

ATTEST:

MIKE COONEY, Secretary of State

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